DESIGN AND FIELD EVALUATION OF A FUEL FILTRATION/ADDITIVE UNIT (FAU)

INTERIM REPORT
BFLRF No. 288

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A Fuel Filtration/Additive Unit (FAU) was designed, fabricated, and field tested. The FAU is capable of removing water and particulate debris from vehicle fuel cells and returning the clean fuel to the fuel cell. In addition, the FAU is capable of on-line addition of additives to convert Jet A to JP-8 or treating microbiological growth with a biocide.

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EXECUTIVE SUMMARY

Problems and Objectives: Historically, the military stores vehicles and equipment with full fuel cells for long periods of time. Also, during maneuvers, vehicles such as the M1A1 combat tank do not use all the fuel or only "top off" the rear fuel cells, since the front fuel cells are difficult to reach. Under these circumstances, the fuel deteriorates and absorbs moisture. Under these conditions, degradation products are formed, free water is accumulated, and microbiological growth may begin. These products will quickly plug the fuel filters, disabling the vehicle. These fuel-related problems have affected many units to such an extent that they are well below combat-ready status. During Operation Desert Shield/Storm (ODS), fuel cells in entire battalions required cleaning before they could be transported to the battle area.

The objective of this program was to design, build, and demonstrate the concept of a mobile piece of equipment capable of cleaning contaminated fuel and dispensing the fuel additives for microbiological growth control and fuel stability.

Importance of Project: A mobile Fuel Filtration/Additive Unit (FAU) could remove contaminated fuel from the vehicle, filter particulate and water, inject required additives, and return the clean fuel into the vehicle. This FAU would allow for the military units to remain combat ready and to reduce maintenance, cleanup, and fuel filter replacement costs. An additional capability of the FAU is that it can convert Jet A-1 into JP-8 for the Army's "Single Fuel on the Battlefield Concept."

Technical Approach: A mobile Fuel Filtration/Additive Unit was designed. The unit has the capability of filtering dirty or contaminated fuel, injecting additives into the clean fuel, and returning the fuel into the vehicle.

Accomplishments: The FAU has been fabricated, qualified, and field tested. The field testing included an emergency contamination problem in which up to 80 percent of a battalion was having fuel-related problems. The FAU was able to clean the fuel cells and return the unit to combat-ready status in a short period of time.

Military Impact: The development of the FAU allows for a simple and rapid means for the military to clean and additize fuel containing gross quantities of particulate and water. The additive system is also capable of converting Jet A-1 to JP-8.

FOREWORD/ACKNOWLEDGMENTS

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Special acknowledgments are given to Messrs. Howard Chesneau, Fuel Quality Services, Inc.; Sim Christie, Jr., Industrial Diesel Systems, Inc.; and Al Hayden, Gate City Equipment Co., Inc., for their design and fabrication of the Fuel Filtration/Additive Unit. BFLRF technician G.L. Phillips' efforts in evaluating and operating the FAU are gratefully acknowledged. Special efforts of Mr. J.W. Pryor and Ms. L.A. Pierce of the BFLRF documents processing group are also appreciated.

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I. INTRODUCTION AND BACKGROUND

The military has encountered fuel stability-related problems for over 30 years. These problems have occurred as far away as Diego Garcia in the Indian Ocean and coast-to-coast in the continental United States. When vehicles use this contaminated fuel, they frequently encounter massive fuel-filter plugging. The constituents in the fuel that plug the filters include: 1) inorganic compounds, i.e., sand, dust, and dirt; 2) fuel-container surfaces, i.e., resins, fiberglass, polyurethane foams, and elastomers; 3) fuel filter media; 4) microbiological products, i.e., fungus, yeast, and bacteria; and 5) organic products, i.e., fuel-derived sediment and gum.(1)* In addition to these contaminants, the fuel cells breathe due to temperature changes. This process brings moisture into the fuel cells. The excess moisture then accumulates and settles to the bottom of the fuel cell. Besides the water itself being a problem, free water is an ideal media for the growth of microbiological products. The design of fuel cells on armored vehicles is furthering complicating this difficult problem. Generally, the fuel cells have unconventional designs, containing many hidden traps for water and debris. Even if a drain plug exists, not all the water and debris will drain. Heavily armor these areas and you have fuel cells that have poor access and which are very difficult to properly clean.

Historically, the military has not been able to maintain these problem vehicles without great expense and time. Many times, the only method for cleaning the fuel cells involved completely removing the power pack. Even this power-pack removal did not completely solve the problems.

During Operation Desert Shield/Storm, at Ft. Hood, TX, whole battalions had to have their fuels cells cleaned before the M1A1 battle tanks could be driven to the railcars for shipment to Saudi Arabia.

Even in Saudi Arabia, other fuel problems surfaced. The military had decided to use JP-8 as the "single fuel on the battlefield." This concept had been successfully demonstrated in a JP-8 Fuel Demonstration Program conducted at Ft. Bliss, TX.(2, 3) However, most vehicles in Operation

* Underscored numbers in parentheses refer to the list of references at the end of this report.

Desert Storm had to operate on Jet A-1 fuel. This use of different fuels created further fuel filter plugging problems.

The military preferred to operate its vehicles and equipment on JP-8, which contains a corrosion inhibitor, fuel system icing inhibitor, and a static dissipator required by the military for aviation-type fuels.(4) However, only limited sources for converting the Jet A-1 to JP-8 were available, and the Air Force controlled those.

II. OBJECTIVES

The objectives of this program were to design, fabricate, and demonstrate the feasibility of a piece of equipment that could clean fuel contaminated with gross quantities of particulate and water and could dispense additives into the fuel. These additives could either convert Jet A-1 to JP-8 or control microbiological growth, thus increasing fuel stability.

III. APPROACH

The approach was to design and assemble a mobile system capable of pumping fuel from the vehicles and small storage tanks, filtering any particulates and water, injecting additives, and returning the fuel to the fuel cell. The system had to be flexible in operation, yet be user friendly.

When designing this system, as many of these features as possible were incorporated, without making the FAU unduly cumbersome to transport and operate.

IV. DESIGNING THE FUEL FILTRATION/ADDITIVE UNIT (FAU)

In designing the Fuel Filtration/Additive Unit (FAU), certain operation parameters had to be fulfilled. Some of these constraints were: 1) the FAU was to be trailer mounted for field

operations; 2) the pumps were to be either centrifugal or positive displacement pumps capable of transferring fuel at a rate of 227 liters per minute [60 gallons/minute (gpm)] with a 10-foot total head, using a test fuel with a maximum viscosity of 4.1 cSt at 40°C; 3) the FAU had to be capable of supplying its own power, with gasoline-powered engines not being allowed; 4) all fuel-wetted components were to be explosion proof; 5) an additive injection system capable of metering three separate additives into the clean fuel was to be installed (this capability allows for the conversion of Jet A-1 to JP-8); and 6) after processing the fuel, the clean fuel shall contain not more than 2.0 milligrams per liter (mg/L) of solid particulate and less than 25 parts per million free (ppm) water. All design requirements are listed in **Appendix A.**

These requirements were distributed to seven companies and a bid package requested. Of these companies, three returned "no bids" and four transmitted completed bid packages to BFLRF. Of these four bid packages, the low bid failed to meet the requirements specified in the package, and the high bid was too expensive. The contract to fabricate the FAU was awarded to one of the mid range companies due to its creative and flexible design.

V. FUEL FILTRATION/ADDITIVE UNIT (FAU)

The FAU, shown in Fig. 1, consists of four major components: 1) power and pump system, 2) control system, 3) additive injection system, and 4) filtration system. Each system is discussed in detail in the following sections, and a complete parts lists is shown in **Appendix B.**

A. Power and Pump System

A self-regulated 240-V, 3-phase, 1800-rpm generator is powered by a 10-kW air-cooled engine mounted on a steel base with an integrated fuel tank. In event of on-board failure, the unit may be switched to an external power source. A control panel is dedicated to the engine and power system. The controls include: 1) main circuit breaker, 2) AC voltage, current and frequency gauges, 3) DC engine gauges with safety shutdown in case of low oil pressure or high temperature, and 4) emergency stop and emergency power switch.

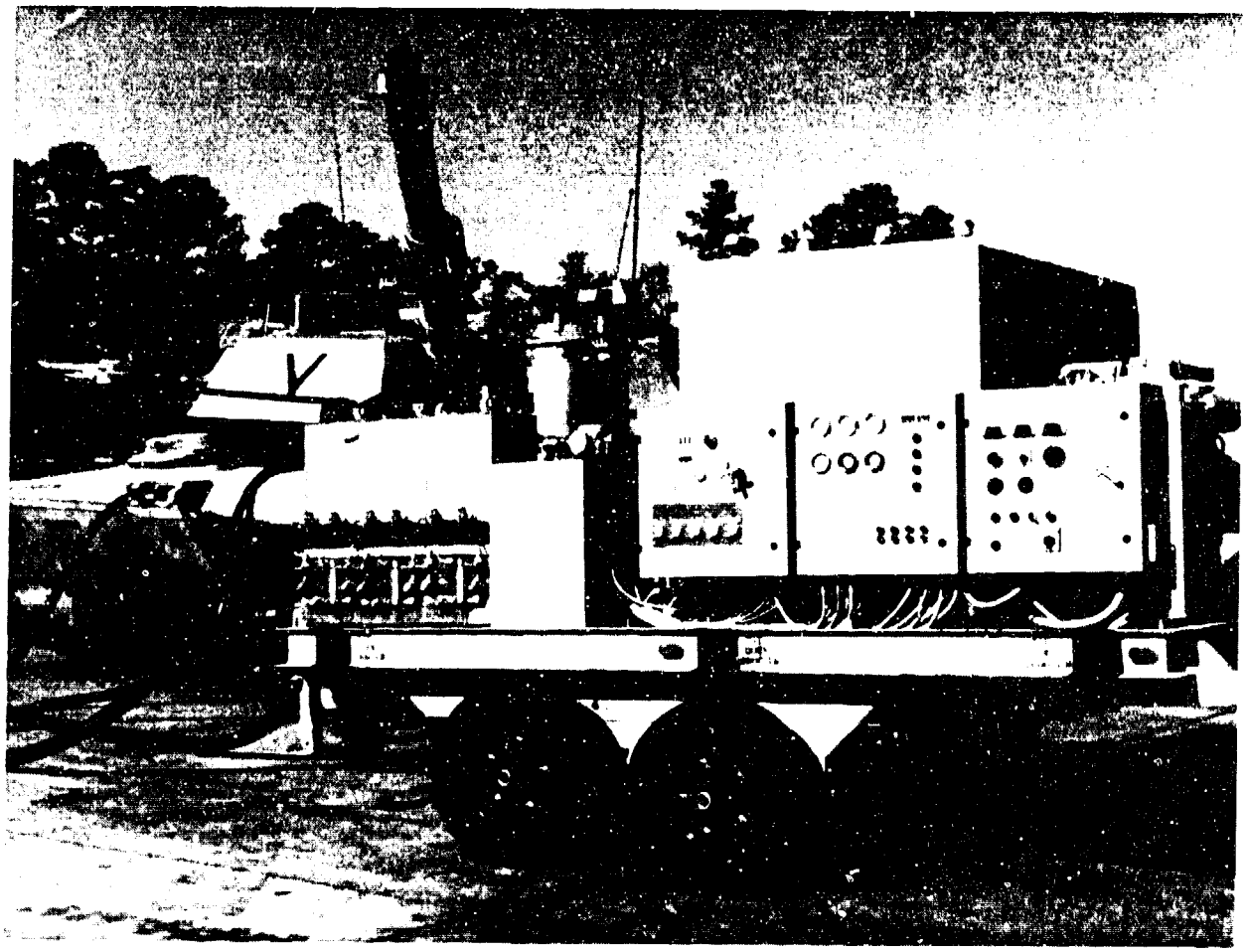


Figure 1. Photograph of Filtration/Additive Unit (FAU)

The pump system uses a positive displacement pump with 5.1-cm (2-in.) fittings. The pump is capable of pumping in excess of 230 liters per minute. A rotary-vane positive displacement pump was chosen for its durability and ease of repair. A 40-mesh wire screen is installed upstream of the pump to protect it from large debris being withdrawn from the fuel cells. The pump is coupled to an hydraulic driver to allow the operator maximum flexibility in controlling the flow rates. This flexibility in flow rates is critical, since the fuel cell openings vary in size. The hydraulic unit has a 150-liter tank powered by a 3.73-kW (5-hp) electric motor. This configuration controls any cavitation that may occur because of the various size hoses required to perform these operations.

A small air compressor activates the pneumatic valves and the additive injection system, and a bypass connection has been included to use air from an auxiliary source if the compressor fails. The system is designed with 5.1-cm (2-in.) plumbing to allow the unit to utilize the maximum flow capacity of the pump. This flexibility will add to the unit's mission capability and allow for much smaller inlet and exit hoses.

B. Control System

All controls are mounted on a control panel conveniently accessible to the operator. From two side-by-side panels, the operator can control the 1) flow rate, 2) various flow loop configurations, and 3) the additive injection system. The operator can also monitor 1) the differential pressure across each filter housing, 2) fuel pressure, 3) warning lights for low fluid and high temperature in the hydraulic system, high water in the fuel/water filter separator housing, and low level in the storage tank, and 4) air pressure.

C. Additive Injection System

The additive injection system is designed to inject up to three separate additives into the fuel with or without prior filtration of the contaminated fuel. An injector, Fig. 2, installed on each additive tank is calibrated for various injection rates ranging from 0 to 3,500; 0 to 5,000; and 1 to 10,000 parts per million (ppm).

The injector uses the on-board air supply to shift a piston inside a cylinder, forcing additive into the fuel stream. The injector is paced using an in-line flowmeter with a multiple head transmitter mounted to the meter. Two pulsers are attached to the transmitter. The first pulser is pneumatic and is used to pace the injection system. The second pulser is digital and provides the electronic output to record the flow rate through the meter and the fuel being additized. The additive selector system is also designed to permit each injector to be used independently, according to the additive requirements of the fuel.

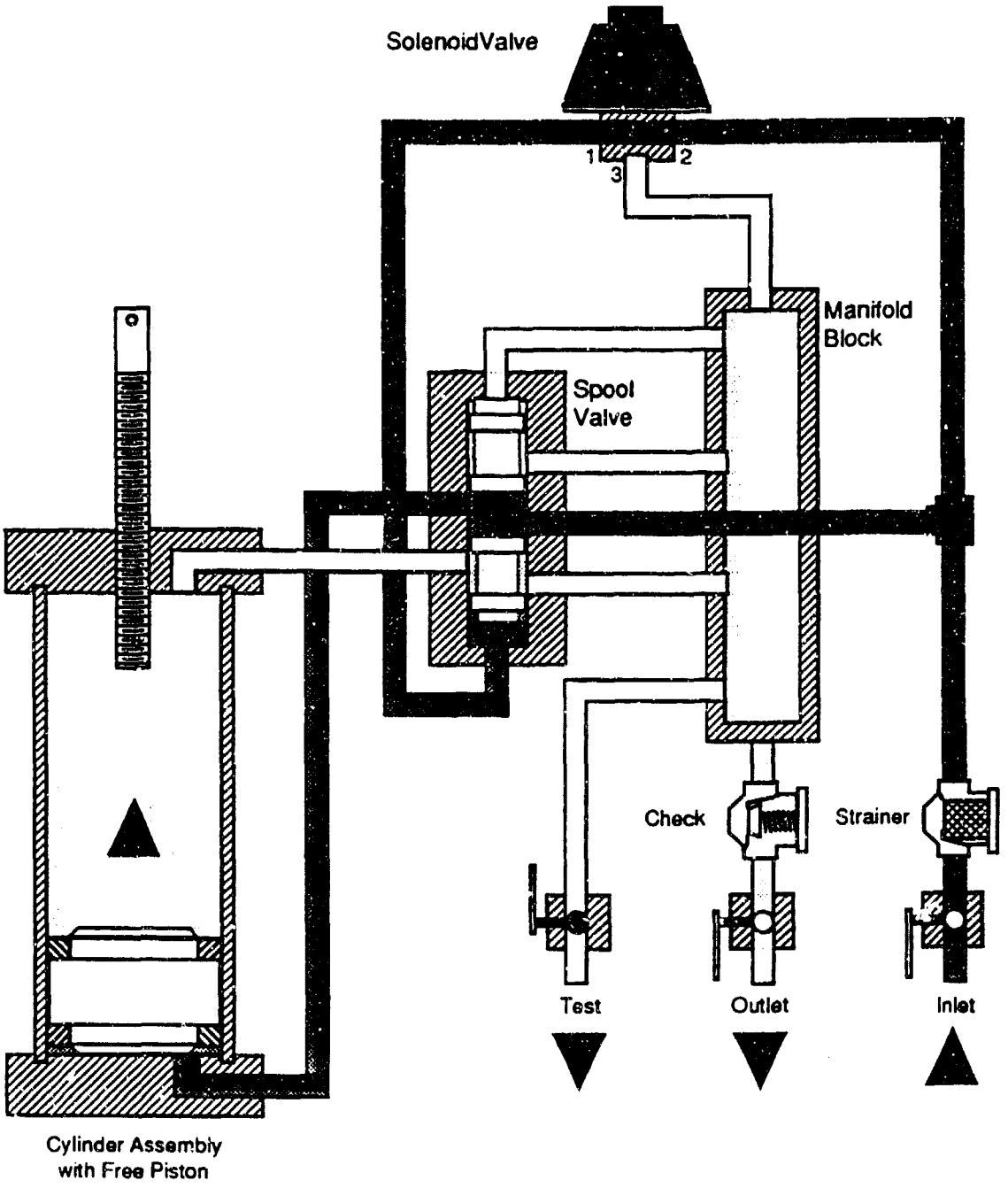


Figure 2. Diagram of injector

An air-logic system, using a minimum of 483 kPa (70 psi) air pressure, was specifically designed to operate the control valves using a sequenced step-through procedure. As a result, the five logic buttons must be activated in numerical sequence. This numerical sequence requirement prevents accidental engagement of incorrect valves during the system operation. A separate

single-button system permits the operator to quickly additize the fuel by bypassing the filtration system and the normal numerical sequence. This feature is useful when treating fuel containing microbiological contamination or for on-line conversion of Jet A-1 to JP-8 fuel.

D. Flow-Loop Configurations

The FAU is designed for flexibility. The flow loop/additive injection control panel allows the operator to select from five possible configurations, depending upon the desired function. The flow loop in each configuration is determined by controlling six air-actuated valves. The functions addressed by the FAU include:

- **Initial Additive Injection** — This configuration permits treatment of the fuel with MIL-S-5 021 (biocide and fuel stability additives) or other approved additives before the filtration process begins or for converting Jet A to JP-8 fuel.

- **Open Flow Loop** — This configuration, which is the first loop in the numerical sequence, pumps the dirty fuel from the fuel cell, through the filtration system, and returns clean fuel into the fuel cell. The return fuel agitates settled debris in the fuel cell, thereby permitting as much debris and water as possible to be pumped through the filtration system.

- **Extraction of Fuel into the Holding Tank** — The second loop in the numerical sequence permits the operator to pump the fuel from the fuel cell(s) into a 2300-liter storage tank. Thus, all fuel is removed from the vehicle in preparation for the next operation.

- **Closed Filtration Loop** — The third loop in the numerical sequence allows the operator to recirculate the fuel in the storage tank through the filtration system until the desired degree of cleanliness is obtained.

- **Additive Injection and Replacement of the Fuel Into the Fuel Cells** — The fourth and final loop of the numerical sequence allows the injection of one to three additives (MIL-S-53021 or other approved additives) into the filtered fuel and to return the additive-treated clean fuel to the fuel cells.

E. Filtration System

The filtration system is the heart of the FAU and consists of three separate housings that can use either conventional or threaded base elements. Each filter housing has its own function, depending upon the severity of the fuel contamination.

Water is the most prevalent contaminant in the military fuel systems. Thus, the first housing contains the fuel-water separator, which consists of two water coalescers and one separator filter. The pickup line is generally placed near or on the bottom of the fuel cell so as to remove as much debris and water as possible from the fuel cell and to agitate any loose debris to allow it to be filtered. The fuel-water separator is the first in-line filter to remove most of this free water and to protect downstream filters from excessive water.

The second housing may contain one of a variety of fuel filters, depending upon the filtration requirements. If additives are to be extracted from the fuel, an activated clay filter should be used. The fuel-water separator will protect the clay filter from being quickly depleted by excessive water. If large quantities of water are encountered or additional water protection is required, a polymeric-type water-absorbing element should be used to absorb and trap the free water. Increasing differential pressure will indicate when the filter is saturated with water. If heavy particulates and light water are encountered, a pleated paper element of the preferred micrometer rating should be used.

The third and final housing can utilize a variety of particulate filters. This filter should extract at least the smallest particle that is potentially damaging to the hardware. At the present time, a rated 0.5-micrometer element is used. However, if extra protection is desired, elements as low

as 0.1 micrometer may be installed. This filtration configuration provides the flexibility to handle most fuel contamination problems that occur in the field.

VI. OPERATIONAL VERIFICATION OF THE FAU

The FAU operation was verified at the manufacturer's facility and was witnessed by BFLRF and Belvoir RDE Center personnel. The FAU was tested using approximately 1700 liters of locally purchased diesel fuel. The FAU was first tested using clean fuel to determine if all components operated properly. The test fuel was then contaminated with AC Fine Test Dust, a sludge/water slurry, and clean water and recirculated in the holding tank with a transfer pump to ensure that the contaminants were thoroughly mixed. Samples of the test fuel were taken before entering and after leaving the FAU and analyzed for particulate and water concentrations.

The affluent (upstream) samples contained 39.0 milligrams per liter (mg/L) of particulates and 2030 parts per million (ppm) of water. The effluent (downstream) samples contained 1.0 mg/L particulates and 150 ppm water. Both analyses were performed according to ASTM procedures.(5)

VII. FIELD EVALUATION

A. 24th Infantry Division (Mechanized), Ft. Stewart, GA

The FAU had an immediate mission at the 24th Infantry Division (M) at Ft. Stewart, GA. The 24th Infantry Division was experiencing numerous problems due to dirty fuel plugging fuel filters. Ft. Stewart supplied BFLRF with three fuel samples, a plugged filter, and a small amount of material that had been removed from the side of a tank on an HEMTT refueler to be analyzed. Two of the samples were from the Ft. Stewart main storage tank, Evans tank farm (a middle sample and a bottom sample). The third sample was obtained from the rear fuel cells on an M1A1 battle tank. All three samples contained visible particulate and the bottom sample from the bulk supply also contained some undissolved water. Only the bottom sample from the bulk

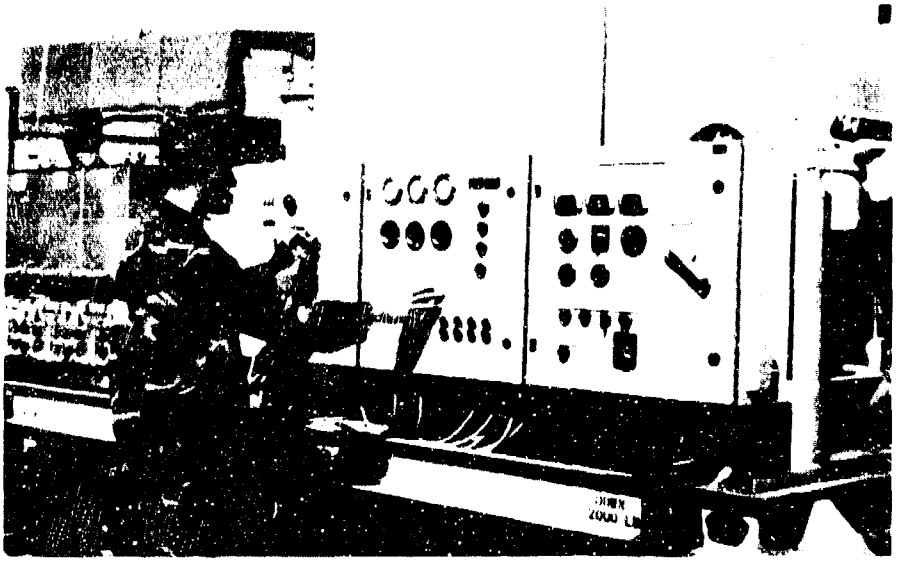
supply had a particulate contamination level (12.4 mg/L) in excess of the specification limit 10 mg/L. The results from these analyses showed that the fuel was not contaminated with residual fuel or used lubricating oil; in general, these samples were clean and stable.

Infrared (IR) spectra analysis was performed on the debris removed from the plugged fuel filter and HEMTT samples. The spectra contained no indication of microbiological debris, but were consistent with the presence of fuel degradation products, while the spectra for the HEMTT sample had a small adsorption consistent with the presence of microbiological contamination.

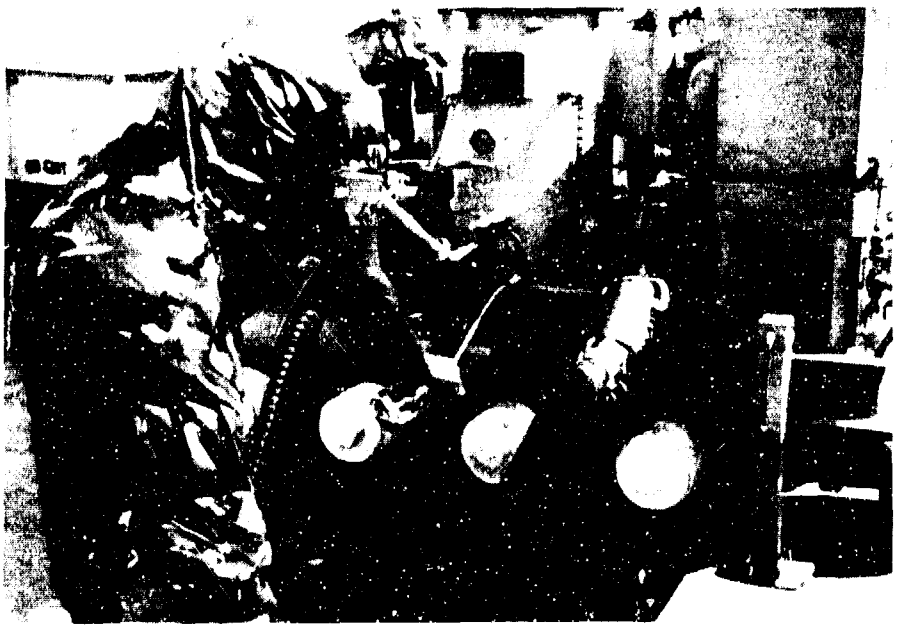
BFLRF personnel visited Ft. Stewart to investigate these reported problems. Examination of the fuel in the M1A1 battle tanks in the field revealed few problems. These were the vehicles that had experienced the initial problems. During maneuvers, these vehicles had "worked" their way through the problems by consuming the contaminated fuel and multiple fuel filter changes. Examination of vehicles preparing for maneuvers revealed the problems experienced previously. The first sample was black in color and very highly contaminated with particulates. The second sample contained much free water and particulates, but no indication of microbiological activity. Tank crews indicated that, in some cases, the fuel in the front fuel cells had remained untouched for more than a year.(6) Note: Ft. Stewart uses a biocide at its fuel farm to control microbiological contamination. The FAU was air-shipped to Ft. Stewart for immediate decontamination of M1A1 battle tanks, M113 personnel carriers, and an assortment of other vehicles.

Military personnel from the 24th Infantry Division (M) were trained in the use of the FAU for approximately 1 week and supervised during operation for an additional week, Fig. 3.

As shown in Fig. 4, the fuel was heavily contaminated with both water and particulate. The water contamination is generally created by the fuels cells "breathing." In geographical areas with high humidity, the air contains large quantities of moisture, which condenses when ambient temperatures decrease. The heavy, black particulate debris is fuel degradation products,



a. 24th ID (M) soldier operating FAU



b. 24th ID (M) soldier sampling inlet fuel to determine cleanliness

Figure 3. Photographs of military personnel being trained in the use of the FAU

which is common in the military environment.(7) Fuel stability is not infinite. Therefore, with time, the fuel will begin to break down, forming particulates and gum [toluene-acetone-methanol

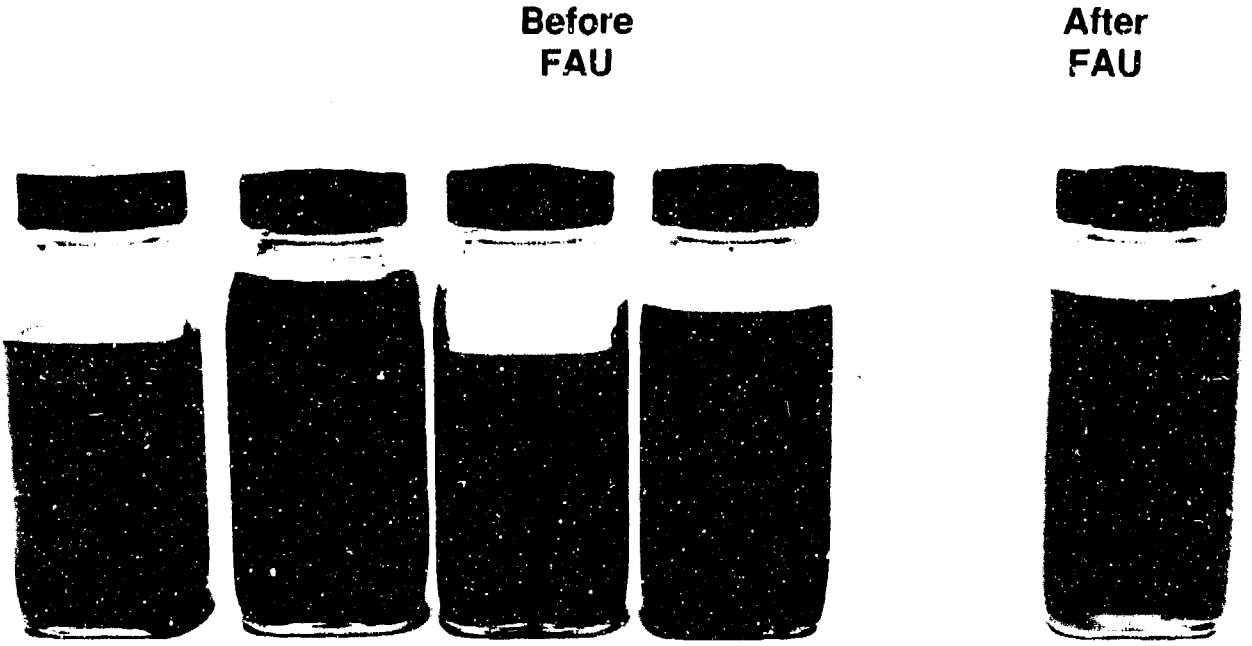


Figure 4. Fuel sample from M1A1 and M113 front fuel cells

(TAM) insolubles]. Some of the black debris may be residual microbiological growth, which has been killed with the biocide portion of MIL-S-53021 that Ft. Stewart uses. Also, Fig. 4 illustrates that the FAU is capable of removing these contaminates and returning "clean and bright" fuel to the fuel cell. Additional contaminates were removed from the 40-mesh wire screen that protects the pump (Fig. 5). The main component that plugged this screen was a tarry asphalt-like material. This tarry material contained other contaminates such as: 1) fiberglass shavings, 2) check valves, 3) paper, and 4) elastomer materials (Fig. 6). Fig. 7 illustrates the large quantity of toluene/acetone/methanol (TAM)-insoluble material present. This material is an indication of inorganic or high molecular weight resinous materials that help plug the fuel filters. Fig. 7 also illustrates the presence of metallic flakes in this composite. In general, a fuel filter will not encounter all these materials, but, obviously, many were encountered during these operations.

An interesting observation concerning the M1A1 filtration system was that the primary filter was the only filter plugged when the maintenance personnel needed to change filters. The final

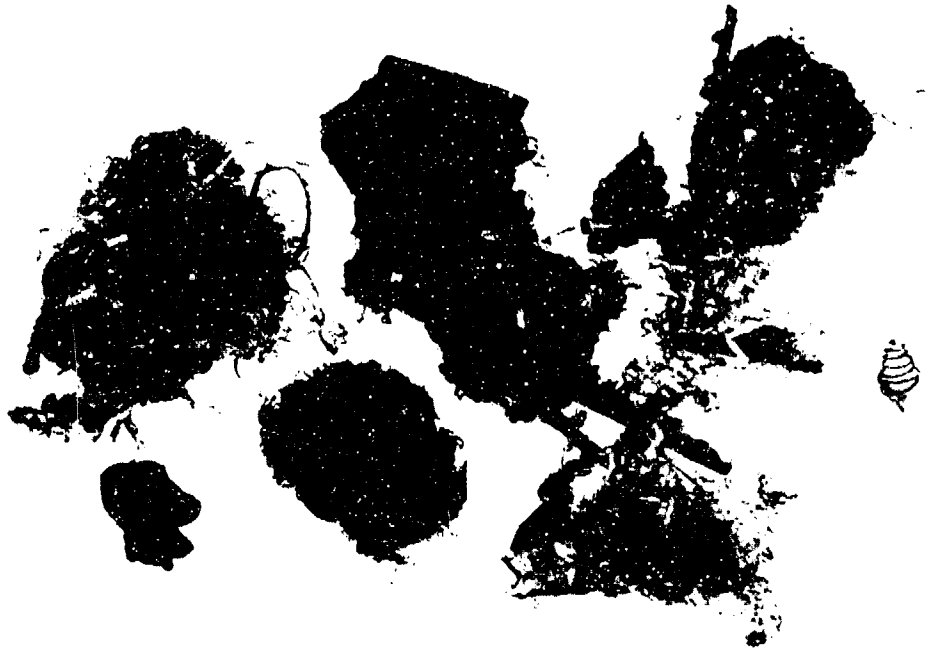


Figure 5. Debris from an M1A1's front fuel cell collected in a 40-mesh wire screen

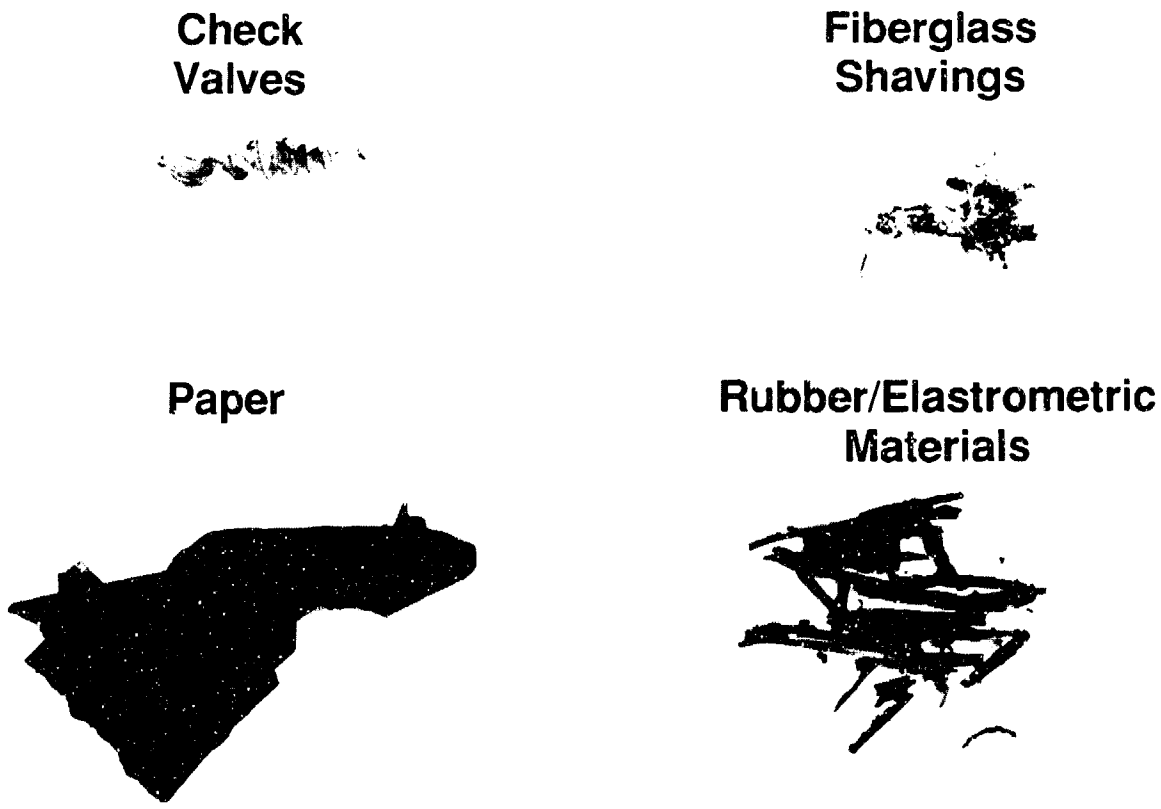


Figure 6. Photograph containing check valves, fiberglass shavings, paper, and rubber/elastomeric materials

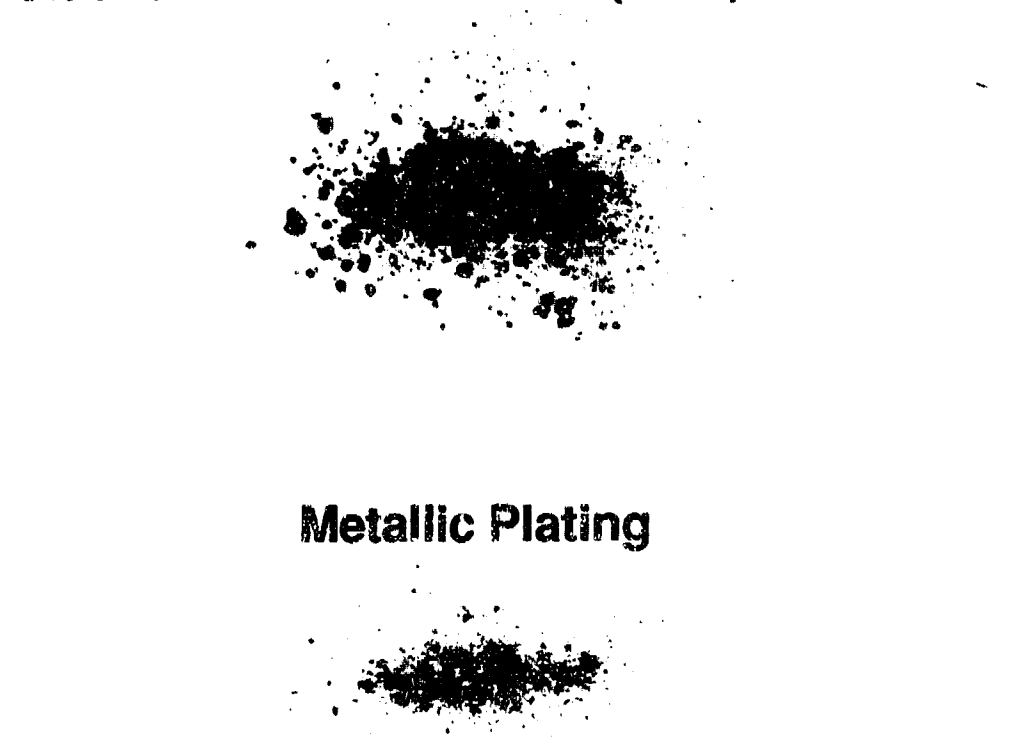


Figure 7. Photograph illustrating toluene/acetone/methanol (TAM) insolubles and metallic plating

(secondary) and coalescer filters were relatively clean (Fig. 8). When military personnel order replacement filters, a complete set of four filters is received. In instances such as these, three of the filters do not require replacement. Replacing the three still usable filters each time the primary filter is replaced results in additional costs and maintenance time and increased filter disposal problems.

During this exercise, 323 vehicles were inspected to determine fuel quality. Of these vehicles, 243 had the fuel processed through the FAU. Since this operation frequently encountered excessive water, the polymeric-type water-absorbing filter element was used in the second housing. An after-action memorandum from the 24th ID DISCOM reported satisfaction with the FAU and a continuing need for its deployment, Appendix C.(8)

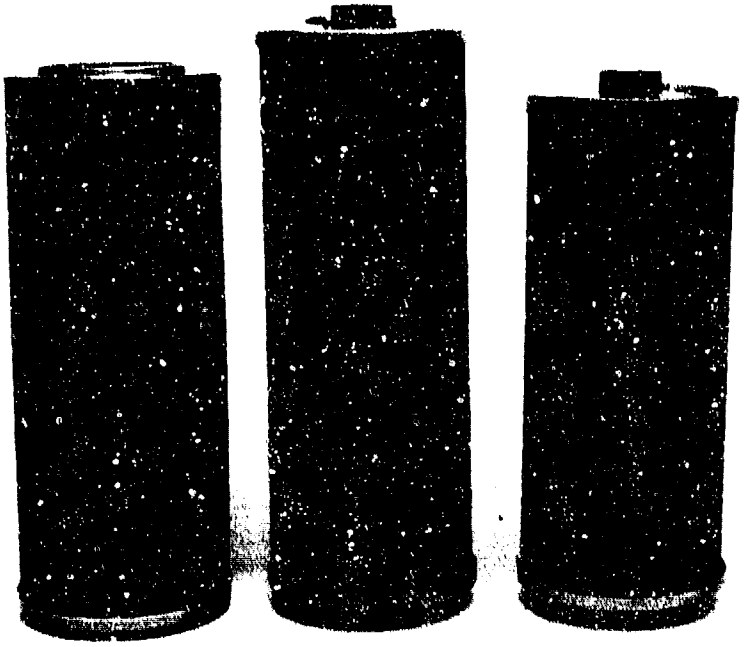


Figure 8. Set of fuel filters removed from an M1A1 experiencing plugged fuel filters

B. U.S. Marine Corps, Camp Pendleton and Twentynine Palms, CA

Use of the FAU was requested by the U.S. Marine Corps, 1st Reconnaissance Battalion, Light Armored Vehicles (LAVs), at Camp Pendleton, CA.(9) The FAU was transported via truck to Camp Pendleton. The LAVs were experiencing filter plugging problems similar to those found at Ft. Stewart, GA, Fig. 4, due to fuel degradation products and water contamination. However, it was found that due to the use of FOA-15, the Fuel Oil Additive portion of MIL-S-53021, the fuel degradation products were smaller. This particulate tended to plug the final, 0.5 micrometer, filter on the FAU, instead of the middle, 5 micrometer, filter.

A gunnery sergeant was trained to operate the FAU and successfully cleaned the fuel cells on 93 LAVs. Once this operation was completed, Twentynine Palms requested that the FAU be transported there to clean contaminated fuel from M1A1 battle tanks that was drained into an underground storage tank. Once Twentynine Palms personnel realized the potential of the FAU, select vehicles were also processed.

An after-action letter (point paper) from Camp Pendleton, 1st Reconnaissance Battalion reported satisfaction with the operation and capabilities of the FAU, Appendix D.(10)

C. FAU Modifications

After completion of the field evaluations, several modifications were determined that would make the FAU more user friendly and allow for longer operability. These modifications included:

- Replace starter switch with on-switch and starter button,
- Redesign the hydraulic system to allow for operation at lower flow rates. This modification also included installing a fluid/water separator on the hydraulic system, heat exchanger, and new flow control on the control panel.

VIII. CONCLUSIONS

A mobile fuel filtration and additive system was needed in the field for cleanup and additization operations on U.S. Army vehicles and equipment. The FAU, designed and fabricated to solve these two problems, is capable of cleaning extremely dirty fuel containing large quantities of free water. This capability saves the Army time and money in maintenance and in the cost of replacement filters. The FAU has already demonstrated its benefits in the field and ease of use to the Army in its recent cleanup effort at Ft. Stewart, GA, and with U.S. Marine Corps units at Camp Pendleton and Twentynine Palms, CA. Upon completion of the Ft. Stewart and Camp Pendleton operations, Camp JeJeune, NC, Ft. Carson, CO, and Ft. Knox, KY, expressed interest in using the FAU. However, at the time, these bases were unable to obtain the necessary funding needed to transport the FAU, provide the needed training, and monitor the overall operations.

The design and results of the field demonstrations were presented to the 1993 Society of Automotive Engineers (SAE) International Congress and Exposition, held in Detroit, MI, 01–05 March 1993.(11)

IX. RECOMMENDATIONS

The current FAU model was designed to prove the concept that a trailer-mounted filtration/additive system was feasible and valuable to military logistic and maintenance communities. This design now needs to be militarized to be functional in the military environment. A proposal has been submitted to U.S. Army Belvoir Research, Development and Engineering Center to militarize the FAU and improve the operation using suggestions generated by the soldiers in the field.

Currently, U.S. Army Belvoir Research, Development and Engineering Center is attempting to expedite the production of the FAU by actively pursuing an Operational Need Statement (ONS) with the assistance of Ft. Stewart, Camp Pendleton, and endorsement of the memorandum from Ft. Stewart for "Support for Procurement of Fuel Filtration/Additive Unit (FAU)" directed to the Deputy Chief of Staff Operations and Plans, United States Army, Washington, DC.(12)

X. LIST OF REFERENCES

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5. ASTM ES19-91, "Emergency Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration," and ASTM D 1744-92, "Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent."

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8. Colonel Robert Floyd III, Division Support Command, 24th Infantry Division (Mechanized) Support Command, Fort Stewart, GA, memorandum for Commander, U.S. Army Belvoir Research, Development and Engineering Center, Ft. Belvoir, VA, subject Filtration/Additive Unit, dated 7 January 1993.

9. Colonel J.F. Kelly, U.S. Marine Corps, 1st Reconnaissance Battalion (Light Armored), Camp Pendleton, CA, memorandum to U.S. Army Belvoir Research, Development and Engineering Center, Fort Belvoir, VA, subject: "Fuel Filtration/Additive Unit," dated 15 December 1992.

10. Colonel J.F. Kelly, U.S. Marine Corps, 1st Reconnaissance Battalion (Light Armored), Camp Pendleton, CA, point paper for Commander, 1st Marine Division, AC/S Logistics, Camp Pendleton, CA, dated 4 March 1993.

11. Bessee, G.B., Chesneau, H., Christie, Jr., S., and Hayden, A., "Mobile Fuel Filtration/Additive Unit," Society of Automotive Engineers Paper 930015, Warrendale, PA, March 1992.

12. Lieutenant General, GS, John H. Tilelli, Jr., Deputy Chief of Staff for Operations and Plans, endorsement memorandum for BG Joseph E. DeFrancisco, Assistant Division Commander, 24th Infantry Division, Fort Stewart, GA, subject: "Fuel Filtration/Additive Unit," dated 31 August 1993.

APPENDIX A

Design Requirements of Filtration/Additive Unit (FAU)

General Description of Proposed Fuel Filtration/Additive Unit (FAU)

Intended Use: The Fuel Filtration Additive Unit (FAU) is intended primarily to aid in the cleanup of fuel in ground vehicle fuel cells. The FAU will provide a simple and rapid means to remove particulate and water contamination from fuel in Army ground vehicles and equipment. The FAU has three additive injection pumps for addition of additives to the clean fuel. These additive injectors can be used to convert Jet A-1 to JP-8 fuel through the addition of icing inhibitor, corrosion inhibitor, and static dissipator additives. The FAU is to be designed to clean and additive-treat diesel in fuel volumes between 100 and 1200 gallons. The designed pump rate is 60 gallons per minute (minimum) using diesel fuel at its maximum viscosity (4.1 cSt) at 40°C. For larger fuel volumes, other means should be used to keep operating time throughput at a convenient level.

FAU Minimum Requirements

Trailer

1. The FAU will be trailer mounted.

2. The trailer shall not be more than seven (7) feet wide at its maximum width.

3. The tongue of the trailer will consist of an eyelet trailer hitch for use with military vehicles.

4. The trailer shall meet the Code of Federal Regulations "Federal Motor Vehicle Safety Standards" for highway use.

5. The total empty weight of the trailer and all components shall be less than 8000 pounds.

6. The trailer chassis shall be provided with grounding capability using a grounding cable or rod. Grounding shall be provided for the incoming and outgoing fuel connections. In addition, all major components shall be grounded (bonded) to the chassis.

Filter/Coalescer

1. Unless otherwise specified, the filter/coalescer shall be designed to meet the performance criteria of specification MIL-F-8901. The procedure will be modified to use only AC Fine Test Dust and water. (Note: No red iron oxide will be used for this test.) The test fuel used for this test will be Caterpillar 1H2 test fuel.*

2. The fuel filter shall be capable of withstanding a flow rate of 60 gallons per minute (GPM) using a fuel with a viscosity of 4.1 cSt at 40°C.

3. The effluent from the coalescer, or water separator, shall contain less than 10 parts per million (ppm) free water.

Housings/Storage Tank/Piping

1. All filter/coalescer/water separator housings shall be constructed of any material that meets ASME Code, Section VIII construction standards for pressure vessels and is compatible with hydrocarbon-type fluids.

2. A 200-gallon temporary working fuel storage tank shall be provided to allow collection of clean fuel when necessary.

3. The fuel flow scheme shall allow for fuel to be pumped into the 200-gallon storage tank and recirculated through the system for addition of fuel additives.

*Caterpillar 1H2 is a Reference No. 2 diesel fuel, and its specification requirements are set forth in Section 5.2, Methods 354 and 355 of Federal Test Method Standard (FTMS) 791C, and described in Appendix F of the ASTM STP 509A, Part I and II.

4. All piping shall be 2 inches in diameter.

Additive Injection System

1. The additive injection system installed shall be capable of metering three separate additives into the cleaned fuel.

2. The pumps shall be capable of metering the additives into the fuel at a rate of 1 to 1500 milligrams per liter $\pm$ 2 vol% of setpoint. (Note: Any additive that is specified as weight percent will be converted to volume percent.)

Power Supplies

1. Diesel engines shall be used to drive the pump(s) and/or generator for producing electrical power. Note: No gasoline-powered engines or pumps will be allowed.

2. All pumps or solenoid valves and other components that make intimate contact with the fuel shall be explosion proof.

3. The FAU shall not require any external power supply.

4. The FAU shall have the capability of running on external or auxiliary power in case of failure of the on-board generator.

Pumps

1. Pumps may be centrifugal or positive displacement.

2. The fuel transfer pump shall be capable of pumping at a rate of 60 GPM with a 10-foot total head using a test fuel with a viscosity of 4.1 cSt at 40°C.

Extra Equipment and Parameters

1. The FAU shall have one filtration system that is sufficiently monitored to determine when the filters are plugging.

2. The FAU shall have a control panel with all switches and readouts (preferably digital) of flow rates, pressures, etc.

3. Automatic air eliminators shall be installed on all housings.

4. If positive displacement pumps are used, a pressure relief system is required.

5. Sight glasses shall be installed in all housings placed near the top of the housing.

6. Differential pressure gauges shall be installed on each filter or filter/separator housing.

7. Pressure relief valves shall be installed on each housing.

8. Sampling valves shall be installed at the inlets and outlets of each housing and before and after the additive injection system.

9. A removable stainless steel wire mesh screen shall be installed at the pump inlet according to manufacturer specifications.

10. A flow totalizer meter shall be installed in the fuel flow system and for each of the additive units with, preferably, digital readouts.

11. An emergency, master cutoff switch shall be installed.

12. Elastomeric materials used in seals and hoses shall be of the highest quality and fully compatible with the fluids they contact.

13. Manual/automatic water drains shall be mounted on all filter and/or coalescer/water separators.

14. If diesel driven, the engine fuel storage tank shall be sized to allow a minimum of 4 hours continuous operation without refueling, but shall not exceed 118 gallons.

15. A commercially available tool box with the approximate dimensions, 24 inches high × 36 inches wide × 12 inches deep, shall be mounted to the trailer.

16. A 4 inch diameter × 6 foot long PVC tube shall be installed on the trailer for housing any hoses.

17. The FAU will be completed within 180 days of awarding the contract.

18. Materials that are disallowed are copper and copper bearing alloys when in continuous contact with the fluids.

19. All materials shall be compatible with hydrocarbon fluids and fuel additives (Kaython, FOA-15, Anti-Static Additive, and Fuel System Icing Inhibitor).

20. All equipment must be capable of withstanding double the maximum expected operating pressures without failure.

21. The FAU shall be designed to operate at temperatures from 0°C (32°F) to 50°C (122°F) and outdoors without shelter.

22. Clean fuel will be defined as fuel containing not more than 2.0 mg/L of solids contamination and less than 25 ppm free water.

23. The contractor will furnish engineering drawings to BFLRF (SwRI) prior to fabrication.

24. Testing of the system will be required with BFLRF (SwRI) personnel present.

25. The FAU shall meet all necessary safety requirements to ensure personnel safety.

26. The use of systems/components already in the Army inventory or commercially available is encouraged to minimize special designs and costs.

APPENDIX B

Parts List

-FAU-

FILTRATION ADDITIVE INJECTION UNIT

Developed by:
Fuel Quality Services, Inc.
Industrial Diesel Systems, Inc.
Gate City Equipment Co., Inc.
Filterdyne Filtration Systems

TABLE OF CONTENTS

OPERATIONAL SEQUENCE

FILTRATION ADDITIVE UNIT OPERATIONAL SEQUENCE

STEP 1: Open Filtration Loop (Optional)

Operator powers up F.A.U. and turns control switch to position #1. In this step, the necessary control valves are actuated to allow fuel to be pumped from the vehicle, through particulate filters and returned to the vehicle's fuel tank. This step is repeated until all contaminants are flushed from the vehicle's fuel tank.

STEP 2: Extraction of Fuel into Holding Tank

Operator turns control switch to position #2. In this step, the necessary control valves are actuated to allow the fuel to be pumped from the vehicle and into a storage tank aboard the F.A.U.

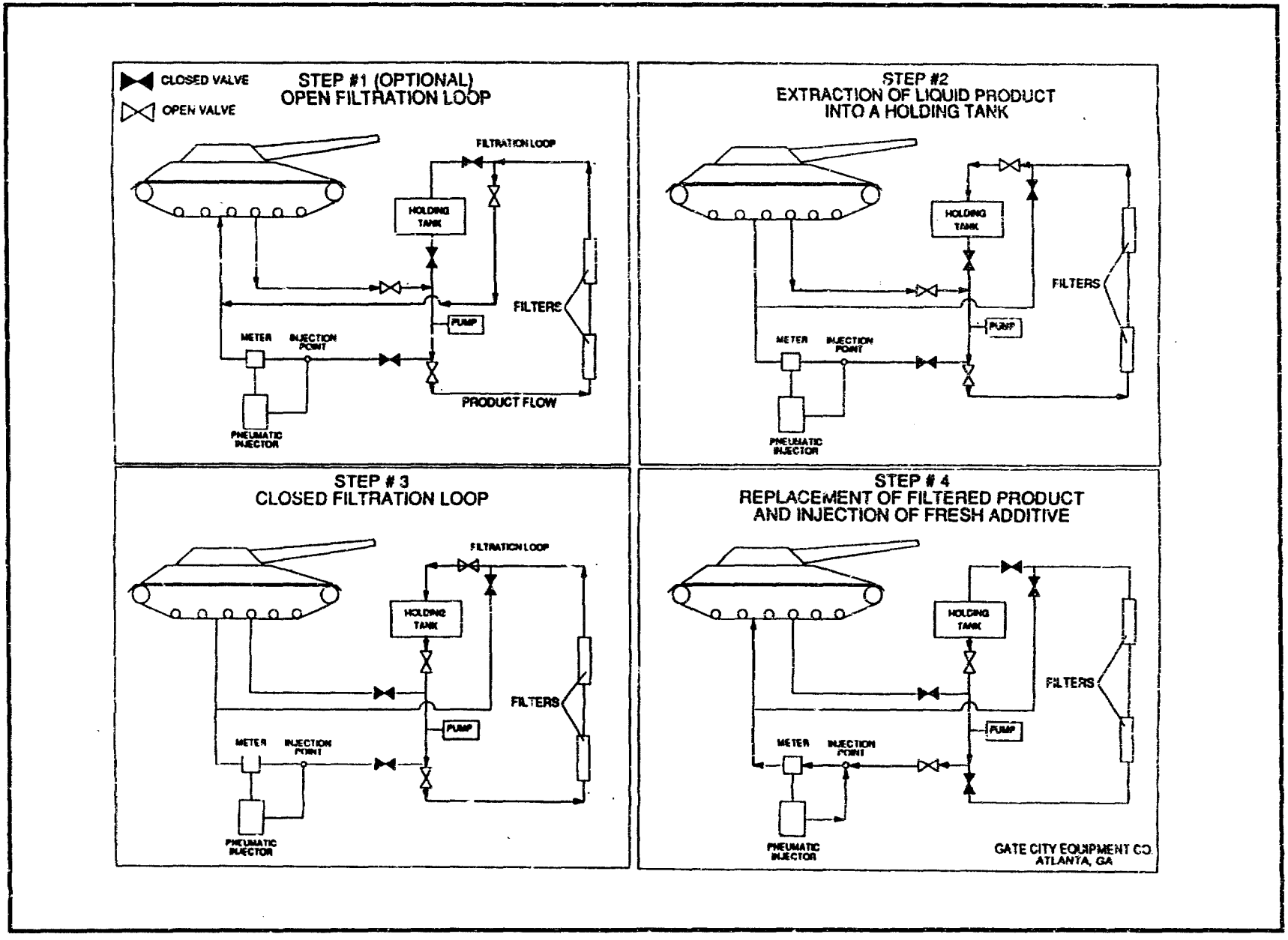
STEP 3: Closed Filtration Loop

Operator turns control switch to position #3. In this step, the necessary control valves are actuated to allow the fuel to be pumped from the storage tank, through particulate filters and returned to the storage tank. This step is repeated for a duration required to remove all contaminants from the fuel.

STEP 4: Additive Injection

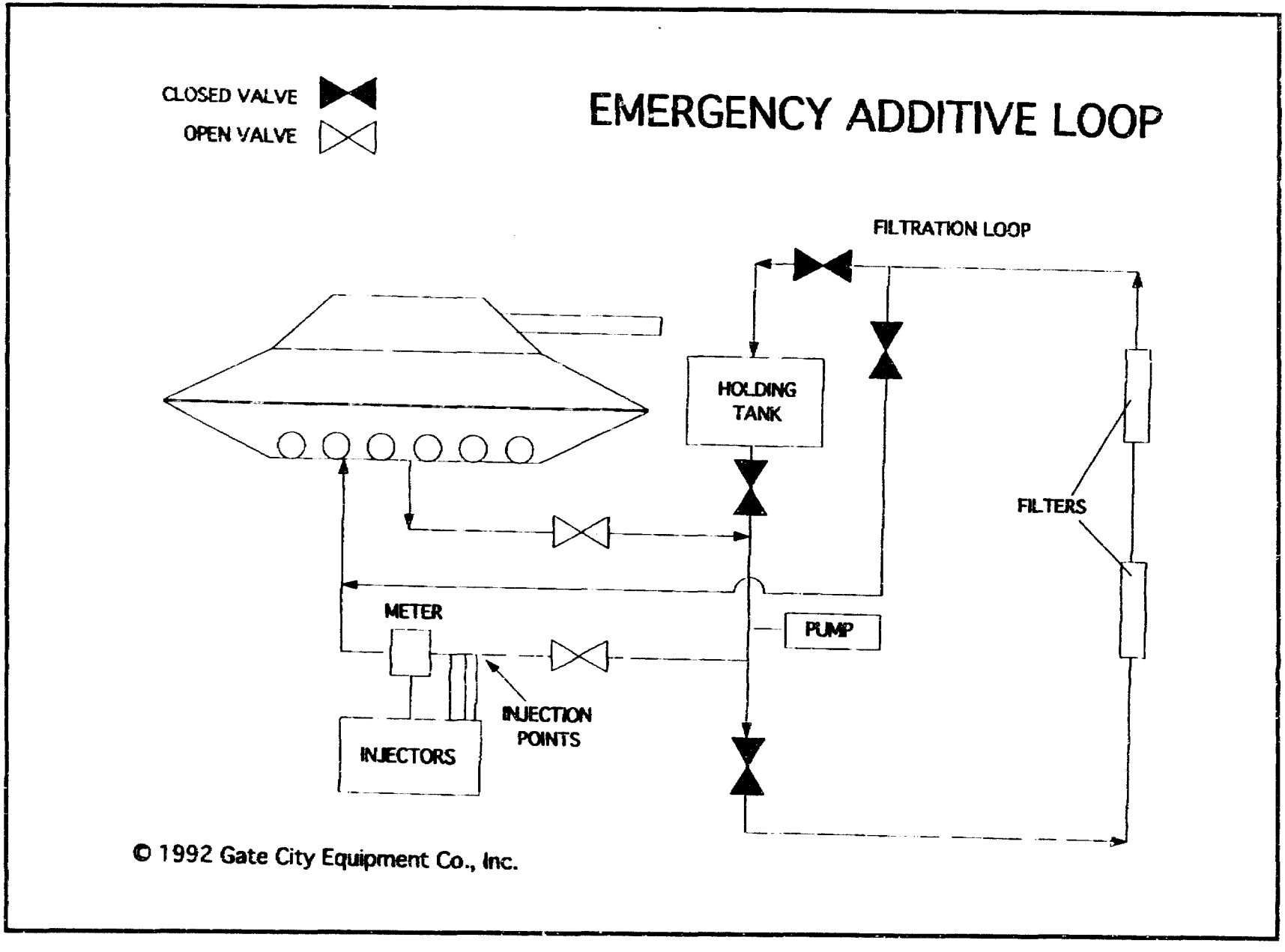
Operator turns control switch to position #4. In this step the necessary control valves are actuated to allow the filtered fuel to be pumped from the storage tank and through a flow meter. After the fuel passes through the meter, the required additives are injected into the fuel and it is pumped back into the vehicle's fuel tank.

*** NOTE: Please refer to the schematic diagram when reviewing the operational sequence.**


CLOSED VALVE
OPEN VALVE
STEP #1 (OPTIONAL)
OPEN FILTRATION LOOP
FILTRATION LOOP
HOLDING TANK
FILTERS
PUMP
METER
INJECTION POINT
PRODUCT FLOW
PNEUMATIC INJECTOR
STEP #2
EXTRACTION OF LIQUID PRODUCT
INTO A HOLDING TANK
HOLDING TANK
FILTERS
METER
INJECTION POINT
PUMP
PNEUMATIC INJECTOR
STEP # 3
CLOSED FILTRATION LOOP
FILTRATION LOOP
HOLDING TANK
FILTERS
PUMP
METER
INJECTION POINT
PNEUMATIC INJECTOR
STEP # 4
REPLACEMENT OF FILTERED PRODUCT
AND INJECTION OF FRESH ADDITIVE
HOLDING TANK
FILTERS
PUMP
METER
INJECTION POINT
PNEUMATIC INJECTOR
GATE CITY EQUIPMENT CO.
ATLANTA, GA

EMERGENCY ADDITIVE LOOP

THE OPERATOR PUSHES THE EMERGENCY ADDITIVE BUTTON AND PRE-SELECTED VALVES OPEN TO ALLOW THE QUICK ADDITIZATION OF THE FUEL IN THE VEHICLE. THIS LOOP BY-PASSES THE FILTERS AND METERS ONE OR ALL THE ADDITIVES INTO THE FUEL.

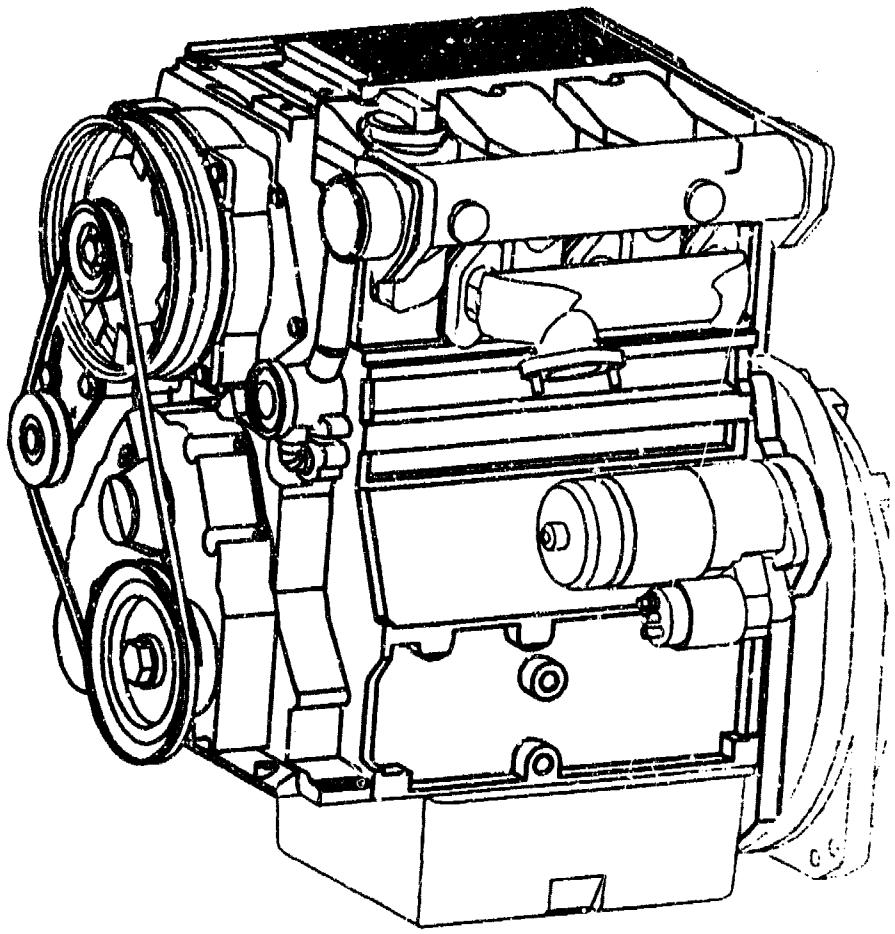

CLOSED VALVE
OPEN VALVE
EMERGENCY ADDITIVE LOOP
FILTRATION LOOP
HOLDING TANK
FILTERS
METER
PUMP
INJECTION POINTS
INJECTORS
© 1992 Gate City Equipment Co., Inc.

ENGINE

ENGINE

DESCRIPTION	MANUFACTURER	S.N./PT. No.
Diesel Air Cooled	Deutz	8222822
Model F3L1011		
Manifold Muffler		
12 Volt Alternator		
Air Cleaner / Dry Type		438 - 4102
Fuel Filter		117 - 4696
Oil Filter		117 - 4417

F3L1011.



Engine Design Description

Working Principle
4-stroke diesel featuring the new DEUTZ direct injection system

Bore/Stroke
81/105 (mm)

Swept Volume
2049 (ccm)

Compression Ratio
18.5

Number of Cylinders
3

Cylinder Arrangement
Vertical in line

Cooling System
Integrated oil + air cooling system (cylinders oil-cooled, cylinder heads air-cooled) with integrated cooling fan

Crankcase Design
Block-type crankcase with integrated liners

Crankcase Breathing System
Closed underpressure-controlled breathing system with diaphragm valve and return connection to the inlet port, the oil mist being utilized for valve seat lubrication

Cylinder Heads
Block-type cylinder heads of grey cast iron

Valve Arrangement/Timing
Overhead valves in the cylinder head, one inlet and one exhaust valve per cylinder, controlled via tappets, pushrods and rocker arms. Timing by low-noise cogged belt

Pistons
Three-ring pistons with two compression rings and one oil scraper ring

Piston Cooling
By spray nozzles with cooling oil

Connecting Rods
Steel drop forgings with straight joint

Main and Gigeon Bearings
Ready-made turnery bearings with aluminum overlay. Four main bearings, one thereof fitted with thrust plates (thrust bearing)

Crankshaft
Nodular cast iron with cast-on counterweights

Camshaft
Steel shaft with driving cams for fuel injection and transfer pumps, seated in the crankcase in binary bearing sleeves

Lubrication System
Forced-feed system with rotor oil pump with internal serrations supplying simultaneously the cooling oil and cab heating circuits (if cab heating is provided)

Engine Oil Cooler
Engine-integrated light metal cooler

Thermostat-controlled Oil Cooler
Engines with cab heating facility have a thermostat-controlled cooling oil circuit

Lube Oil Filtration
Paper-type micro filter with replaceable cartridge, in full oil flow

Fuel Injection Pump/Governor
Individual withdrawable element-type calibrated pumps
Speed governor integrated in front cover

Fuel Transfer Pump
Diaphragm pump

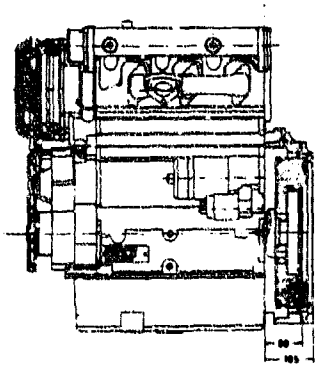
Injector Nozzles
4-hole nozzles

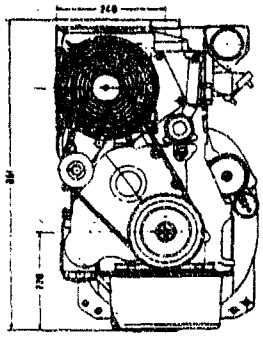
Fuel Filters
Replaceable-cartridge type

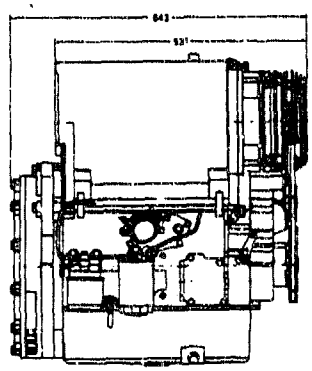
Alternator
Integrated in fan hub,
14 volts, 55 amps (standard)

Starter Motor
2.2 kW, 12 volts (standard)

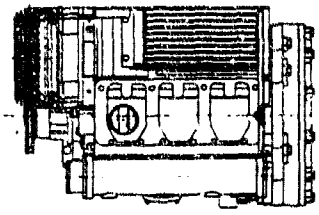
Cab Heating System
Connection facility on engine for cab heating circuit

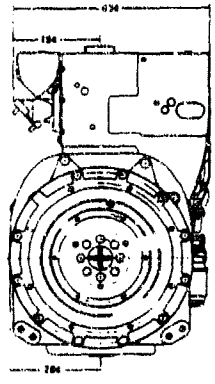






in. = mm x 0.0384



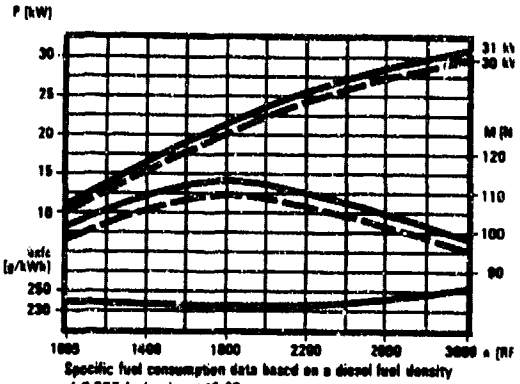


Version Options
- Intake manifold connections
- Exhaust pipes
- Fan guard
- Compressor
- Hydraulic pump
- Engine mounting, rigid or resilient
- Oil pan
- Oil dipstick
- SAE 4/5/6 adapter housing
- Alternator, 12 or 24 V

Maximum Torque

I	Automotive power ratings	M (Nm) n (RPM)	113 1800
II	Highly intermittent operation	M (Nm) n (RPM)	113 1800
III	Intermittent operation	M (Nm) n (RPM)	110 1800

Minimum no-load speed	(RPM)	900
Brake specific fuel consumption at optimal operating point	(g/kWh)	235
Engine weight excl. starter motor incl. alternator, incl. integrated cooling fan	(kg)	202



Specific fuel consumption data based on a diesel fuel density of 0.835 kg/cu.dm at 15 °C

Power ratings for automotive and equipment engines

	Rating categories	n (RPM)	2000	2300	2500	2800	3000
I	Automotive power ratings to RREG 80/1269/EC or ISO 1585	P (kW)	23.0	26.0	27.5	30.0	31.0
II	ISO net brake fuel step power (IFN) to DIN 6271 for highly intermittent operation	P (kW)	23.0	26.0	27.5	30.0	31.0
III	ISO net brake fuel step power (IFN) to DIN 6271, for intermittent operation	P (kW)	22.0	24.5	26.0	28.0	30.0
IV	ISO standard fuel step power (ICFN) to DIN 6271, for continuous operation	P (kW)	21.0	23.5	25.5	27.0	-

Statements refer to the net brake power delivered at the flywheel, incl. power input of cooling fan. Conversion factor to SAE: 1 kW = 1.341 hp

Power ratings for power generating sets

Rating category	n (RPM)	1500	1800	3000	3600
ISO standard power exceedable by 10 % for one hour, with or without interruption, within a period of 12 h	P (kW)	1)	1)	27.0	27.0
ISO net brake fuel step power (IFN) to DIN 6271, for highly intermittent operation, also for standby gensets	P (kW)	1)	1)	30.0	30.0

For further particulars please contact your nearest KHD DEUTZ sales office.

1) Contact head office.

Subject to engineering change without prior notice.

Conversion Factors					
$in.^3$ = l x 61.02	ft/min = m/s x 196.85		PSI = bar x 14.5		lb/HPh = g/kWh x 0.00165
	HP = kW x 1.34		lb/ft. = Nm x 0.737		lb = kg x 2.2

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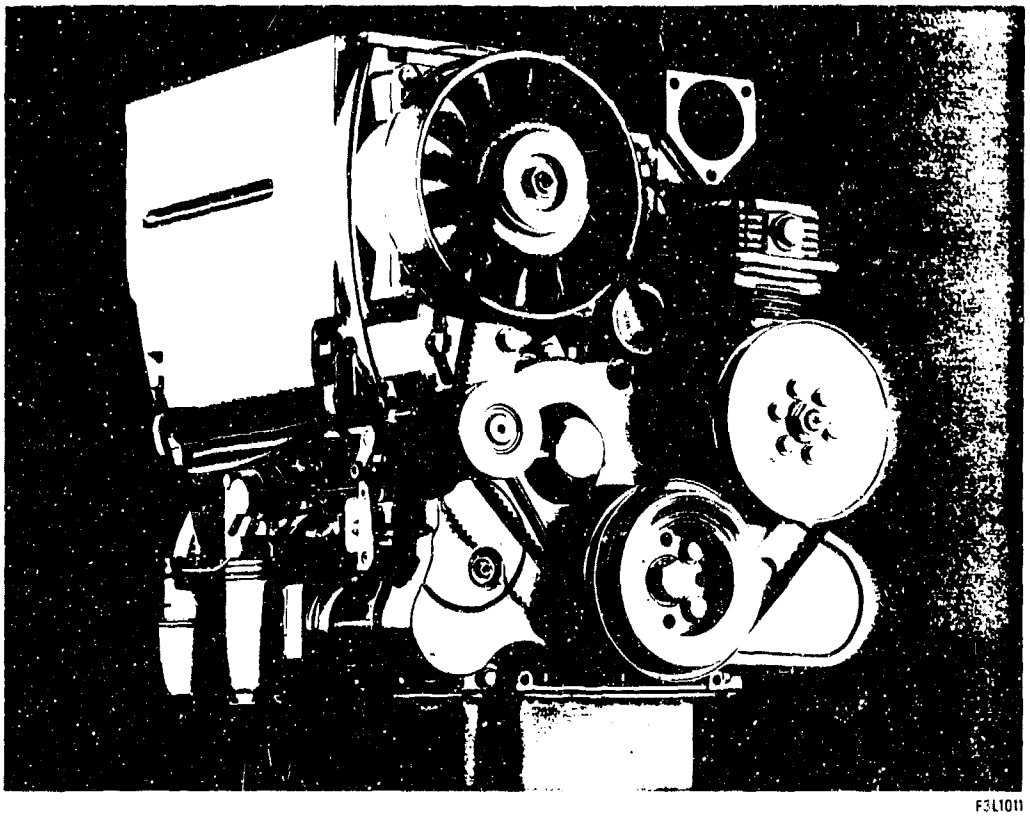
KHD DEUTZ
MEN AND ENGINES



F3L1011

New Engine.

The DEUTZ FL1011 engine family offers future-oriented user-friendly and flexible "all-around" driving packages covering the power range between 10 and 53 kW.

Future-oriented – as they are engines based on technical and social standards which will safely carry us into the future.

User-friendly – as their low vibrations, low noise level, easy operation and excellent cab heating performance are the criteria which define a comfortable working environment.

Flexible – as their great number of optional components makes them a ready match for any given application – a feature inherent to all DEUTZ engines.

Various different power take-off locations render the engine installation low-cost and simple.

New Technology.

In addition to the characteristic KHD DEUTZ quality standards, i.e. high reliability, indifference to extreme ambient conditions, modular construction concept engineered for minimum maintenance and service effort, etc. this engine offers some important innovative features, such as integrated two-media cooling using air and oil, a new DEUTZ direct injection system and an individual injection pump for each cylinder.

New Values

The new FL ten-elevens are bound to be winners thanks to their high fuel economy, reduced pollutant emissions in the exhaust and reduced noise level.

They are outstanding performers in their power class, also in respect of economy and environmental compatibility.

GENERATOR

GENERATOR

DESCRIPTION	MANUFACTURER	S.N./PT. No.
Single Self Regulated 240 Volts 60 Hz 1800 RPM's 3 Phase	Lima	

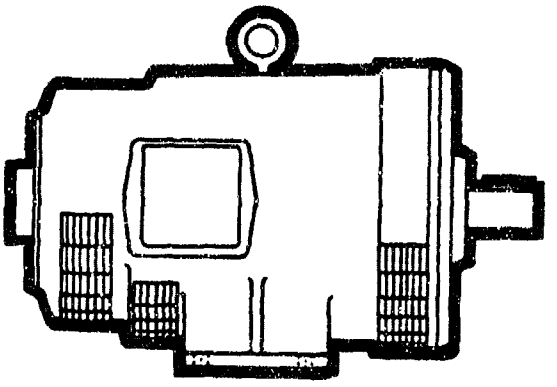
Note: 120 V on single phase, one line of 3 phase is high voltage

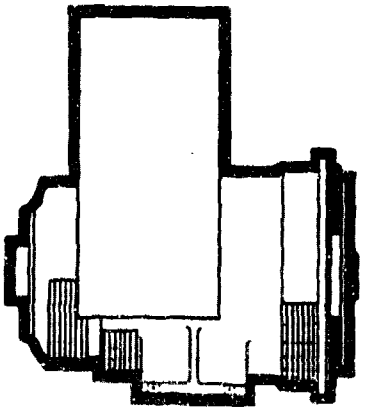
2800M

Electric Company, Inc.

INSTALLATION, OPERATION AND MAINTANENCE MANUAL

TYPE MAC Brushless AC Synchronous, Internally Regulated Alternator Frame 280





The Lima Electric Co., Inc.
P.O. Box 918
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TELEX 242433

Making Energy Work for You

SB 349

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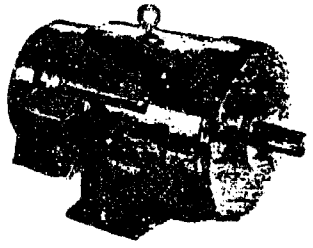
PRINCIPLE OF OPERATION

The MAC generator is a self-regulated, rotating field synchronous unit with the rotor having a salient pole construction with amortisseur windings. The generator stator and exciter stator are combined in a common housing. The generator field, exciter rotor and rotating rectifier assembly are mounted on a common shaft. The output of the exciter rotor is applied to the generator field winding through a rotating, full wave bridge, silicon rectifier unit.

The exciter pole pieces contain residual magnetism, setting up lines of force across the air gap to the exciter armature. When the exciter armature begins to rotate a voltage is induced and current flow is initiated in the exciter armature AC windings. This voltage is fed to the rotating rectifier assembly, rectified and fed to the alternator field coils. This DC voltage is sufficient to magnetize the laminated alternator field which will set up lines of force across the air gap to the alternator stator. As the generator rotor rotates a voltage will be induced and current will flow in the alternator stator windings and to the output circuit.

All connections between the exciter stator windings and the generator stator windings are internally connected within the stator housing. Only the output power leads of the generator unit are brought out to the generator terminal box.



CIRCUIT DIAGRAM

Figure 2 shows the internal schematic diagram of the generator, exciter and rectifier unit. The generator is a three phase unit and the exciter stator and exciter rotor also have three phase windings. A portion of the exciter stator windings is connected across a tap on the generator stator winding. This exciter shunt winding provides the generator field excitation power required for the generator no load voltage. Another portion of the exciter stator windings is connected in series with the output of the generator and provides a compounding excitation characteristic.

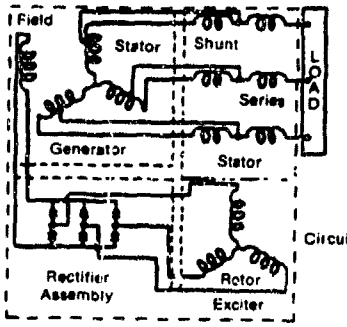


Figure 2 Circuit Diagram

The rotor is, in effect, the secondary of a rotating current transformer induction frequency converter. The exciter rotor output voltage is applied to the generator field windings by a three phase full wave rotating silicon rectifier unit. The response time of the excitation system is very fast since the exciter stator carries an alternating current corresponding to the load current which appears immediately on the exciter primary. An increase in load current will cause an immediate increase in the exciter secondary output voltage which is rectified and applied to the generator field windings. The inherent compounding charachteristics of the excitation system provide excellent voltage regulation even under heavy overload conditions.

PERFORMANCE DATA

The excitation characteristics of fast exciter response with maximum exciter output makes this generator ideal for motor starting loads that require a very high current at low power factor during the motor starting and acceleration periods. At the same time it offers the rugged, reliable, maintenance-free operation inherent in the brushless type generator. No external controls are needed with a Lima MAC generator.

The performance of a 10 kW Lima MAC synchronous generator is indicated in Figure 3.

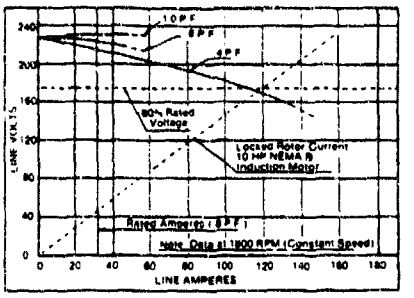


Figure 3

SECTION I
INSTALLATION AND OPERATION

UNPACKING:

When unpacking, check for damage in shipping. Report any damage at once to delivering carrier. Read instruction tags shipped with generator.

INSTALLATION:

The generator must be properly aligned and located in a well-ventilated place where the air temperature will not exceed 40° C or 104° F, and should be accessible for cleaning. An open type generator should not be located where there are abrasive or conductive dusts, corrosive gases or fumes, or where excessive moisture may be encountered. A totally fan-cooled generator should be used where these conditions exist. Air openings of the generator should be cleaned frequently to remove accumulated dust and dirt, which may cause overheating and burn out.

WIRING CONNECTIONS:

Electrical characteristics are shown on the nameplate. Refer to connection diagrams on pages 10 and 11 for proper electrical connections.

OPERATION:

After the generator has been properly connected to the driving unit and the load lines connected to the generator's leads according to the wiring diagram, the unit is ready for operation. To connect the coupling discs of a single bearing generator to the driving engine's flywheel it may be necessary to slide the rotor forward a few inches out of the stator, taking care not to slide it so far as to cause the rotor to come out of the bearing entirely and down upon the stator windings, causing damage to the windings. Ordinarily, a chain hoist is needed to jockey the generator rotor into position.

STANDBY UNITS:

Generators used as an auxiliary power source in case of commercial power failure must be isolated from the commercial line before being placed in operation.

CAUTION: MAKE SURE UNIT IS COMPLETELY SHUT DOWN AND FREE OF ANY POWER SOURCE BEFORE ATTEMPTING ANY REPAIR OR MAINTENANCE ON THE UNIT.

PARALLEL OPERATION:

For parallel operation, both units must be of the same voltage, frequency, and phase. Phase voltages of paralleled units must be synchronized. This generator set utilizes the "dark lamp" method of paralleling.

ROTATION:

The generator can be operated in either direction of rotation.

OVERLOAD:

The load on the generator should be checked with an AC ammeter to see that the ampere rating stamped on the nameplate is not exceeded. Prolonged overload on the generator may cause it to overheat and possibly burn out.

LUBRICATION:

Ball bearings on Lima generators are pre-lubricated and require no further lubrication for the life of the bearing.

SECTION II
SERVICE AND MAINTENANCE

PREVENTATIVE MAINTENANCE AND OPERATING PERCAUTIONS:
Costly repairs and down time can usually be prevented by operating electrical equipment under conditions which are compatible with those at which the equipment was designed to operate. Follow the instructions as outlined to insure maximum efficient utilization of the electrical equipment.

COOLING:
Keep all cooling parts clean and make certain sufficient room is left on all sides for a plentiful supply of fresh coolant air flow. DO NOT EXCEED AIR TEMPERATURE RISE AS SHOWN FOR 50°C ABOVE A 40°C AMBIENT. This insures that the insulation NEMA Class "F" will not be damaged. **DO NOT EXCEED RATED LOAD**, except as specified for the equipment. **OPERATE AT RATED SPEED.** Failure to operate generators at rated load or speed will cause overheating and possibly damage to windings due to over voltage or current.

BEARING REPLACEMENT:
Factor lubricated shielded bearings will normally provide several years of trouble free service when operated under normal conditions. Excessive bearing load and adverse environment conditions will greatly shorten bearing life. Should bearing failure occur, bearings can be replaced. **ALWAYS REPLACE WITH THE SAME TYPE BEARING AS INSTALLED AT THE FACTORY. CHECK PARTS LIST FOR PART NUMBER.** Include generator serial number when ordering bearings.

ROTATING DIODE BRIDGE:
The rotating diode bridge can be removed and replaced. Excessive overcurrent, overvoltage, overspeed, or reverse currents can cause damage to the assembly or any of the component parts.

ROTOR DAMAGE:
The damper bars of the generator prevent excessive hunting when AC generators are operated in parallel. Damper bars, because they must have a low electrical resistance and are subjected to extreme centrifugal forces, must be mechanically secure and permanent. Consequently, they are welded to end plates completely covering the field.

All rotors are static and dynamically balanced to a high degree on precision machines to assure minimum vibration. They will, therefore, remain dynamically stable at speed well beyond the synchronous speed of the generator. The rotors on generators are, however, subjected to extreme centrifugal forces which can increase beyond safe operating limits at excessive overspeed. Therefore, the prime mover should be adequately governed to prevent overspeed.

Damage to the rotor can also occur due to overheating which can be caused by the air flow being restricted from dust or other foreign objects collecting in the air passage.

If a rotor becomes defective, it should be returned to the factory with full nameplate data, because the rotor coils are enclosed in welded squirrel cage winding. To repair a rotor the special tooling and technique of the factory is necessary and essential. The Lima Electric Company, Incorporated, facilities can perform a complete rebuild, or rewind job with greater skill and craftsmanship than can be found in the average motor rewind shop. Should a failure occur, the factory should be notified immediately and steps will be taken to get the generator back into service with the least expense; and more important, to deterime the cause of the failure and take steps to prevent a recurrence.

PRECAUTIONS:
GENERATOR WINDINGS (DRYING):
Generators that have been in transit or storage for long periods may be subjected to extreme temperature and moisture changes. This can cause excessive condensation, and the generator windings should be thoroughly dried out before bringing the generator up to full nameplate voltage. If this precaution is not taken, serious damage to the generator can result. The following steps should be taken to effectively dry the generator windings:

A. (1) Place generator in drying oven or hot room.
   (2) Dry with warm air blower directed through windings.

B. (1) If the generator has been operated and then put into storage for any period of time, a P.D. George #11127 type air-dry fungus resistant varnish should be reapplied.

Experience has shown that it is necessary to take these precautions in locations such as seaboard installations and other highly humid areas. Some installations will be in atmospheres that are much more corrosive than others. A little precaution along the lines outlined here could eliminate an unnecessary repair job.

Each generator was subjected to a standard NEMA insulation test, which means 1000 volts plus twice the highest voltage for which the generator is rated was impressed between the winding and frame. All machines are insulated with a high safety factor for the class of insulation used. The latest and newest in insulation and baking techniques are used.

The finest insulation job can be very quickly broken down carelessly applying high voltage to windings in a moisture saturated condition. Mishandling in this respect can easily cause a breakdown, making it necessary to return the generator to the factory for repair, and consequent expense and loss of time.

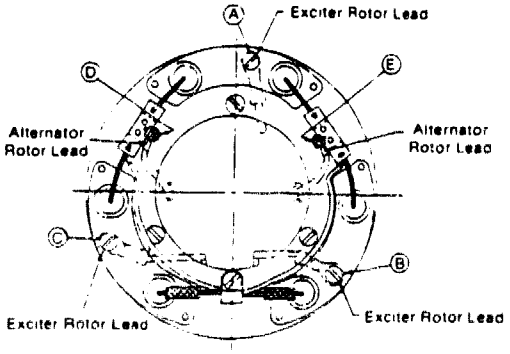
WARNING: HIGH VOLTAGE (DIELECTRIC) TESTING MUST NOT BE PERFORMED TO THE MACHINE WITHOUT FIRST OBSERVING NEMA RULES. THE INSULATION OF THIS GENERATOR WINDING MAY BE SAFELY CHECKED BY USING A MEGGER. A HIGH MEGGER READING INDICATES LOW INSULATION LEAKAGE.

RESTORING RESIDUAL MAGNETISM:
The current necessary to magnetize the alternator field is obtained from the exciter. Initially, upon starting the generator, current flow and voltage are induced into the exciter armature by the magnetic lines of force set up by the residual magnetism of the exciter field poles.

Residual magnetism of the exciter field poles may be lost or weakened by a strong neutralizing magnetic field from any source, or if the generator is not operated for a long period of time.

Should the generator fail to build up voltage after being disassembled for any reason, a momentary short-circuit of any two generator leads should be sufficient to correct this condition. If not, an alternate method may be used. Apply either an alternating current or a direct current voltage of approximately 20 volts to any to generator leads. Do not make a positive connection but rather touch the leads together until the generator voltage begins to rise and then remove. It is suggested that a 30 ampere fuse be inserted in the circuit to prevent any damage in case the build-up voltage is not removed quickly enough.

Start generator and observe generator build-up. Reflash field if generator output voltage does not build up.



Rectifier Assembly 778600
Figure 5

TESTING DIODES WITH AN OHMMETER:
Isolate the rectifier assembly by disconnecting the two leads from the main rotor and three leads from the exciter rotor. Do no unsolder diodes. Test each diode by applying the probes of an ohmmeter to the anode and cathode.

A good diode will produce a meter reading of only a few ohms when the probes are applied in one direction, and a reading of near infinity when the probes are reversed. If both readings are high, or both are low, the diode is defective and must be replaced.

Diode failure after a 25 hour "run-in" period is generally traceable to external causes such as lightning strike, overheating or a reverse current fed into the alternator. To save excessive service time and call-backs, it is a generally accepted practice to replace the entire rectifier assembly where failure can be traced to external causes AFTER THE CAUSE OF DIODE FAILURE IS IDENTIFIED AND CORRECTED.

RECTIFIER REMOVAL PROCEDURE:
Rectifiers may be removed throught the bearing cap on the rear of the generator. (See Figure 6, Item B.) First, remove the bearing cap by removing the four bolts shown in Figure 6 as Item A. You can now see both the bearing (Item C) and rectifier assembly (Item D). Use a bearing puller to remove the bearing from the main shaft being careful to locate the puller on the inner race of the bearing to avoid bearing damage. Once the bearing is free it is then necessary to disconnect leads A, B, C and D as shown in Figure 5 assembly drawing. Then remove the three hold-down cap screws which secure the rectifier assembly to its adaptor. Once this procedure is complete the rectifier assembly is free for removal.

Follow the testing procedures outlined in testing diodes and Figure 5.

After the rectifier assembly has been repaired or replaced, reverse the procedure as stated above, being careful that all lead connections are tight and that set screws are locked with a Lock-Tite compound.

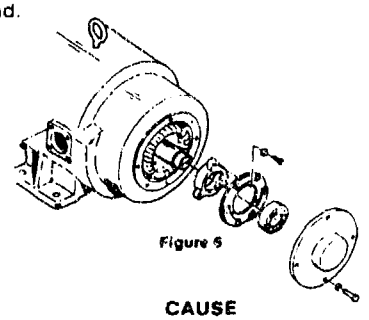


Figure 5

TROUBLESHOOTING PROCEDURES AC BRUSHLESS GENERATOR

As with any machine, trouble may develop in electrical generators. It may be due to long service or neglect of regular maintenance, servicing, and checking. Should trouble develop, the following instructions will be helpful in tracing the cause and making repairs.

SPEED DEVIATIONS:

The generator speed should be maintained at rated nameplate speed. The frequency and voltage of the generator output depends on speed. If the generator runs slower than rated speed, the voltage will drop off.

NO VOLTAGE:

CAUSE	CHECK AND REMEDY
Loss of residual magnetism in exciter field poles.	Flash field, see page 6 "Restoring Residual Magnetism."
Open in stator windings.	Check for continuity in windings. Return to factory for repair if open.
* Open or short in rotating rectifiers.	Check rectifiers per previous instructions, replace if faulty.
Short circuited.	Clear lead to restore voltage build-up.
* Open in alternator field.	Check for continuity and return rotor to factory for repair if field coils are open.
* Shorted exciter armature.	Check for short and replace if faulty. Use a "Kelvin" type bridge to measure this resistance.
* Shorted leads between exciter armature and generator field.	Test and repair.

NOTE: *Designate rotating parts. Generator must be open to test.

LOW VOLTAGE:

CAUSE	CHECK AND REMEDY
Excessive load.	Reduce load. With 3 phase generators, the load on each leg should be as evenly balanced as possible and should not exceed the rated current on any leg.
Low speed.	Check engine for malfunction or system for overload.
Line loss.	Increase size of line lead wire.
High resistance connections — connection will be warm or hot.	Make better connection electrically and mechanically.
Shorted field.	Test field coils for possible short by checking resistance with an ohmmeter or resistance bridge. Return rotor assembly to factory for repair if alternator field coils are shorted.
Low power factor.	Reduce inductive (motor) load. Some AC motors draw approximately the same current regardless of load. Do not use motors of larger horsepower rating than is necessary to carry the mechanical load.

FLUCTUATING VOLTAGE:

(May be indicated by flickering light(s)

CAUSE	CHECK AND REMEDY
Irregular speed of engine.	Check engine for malfunction or load for fluctuation.
Fluctuating speed.	Stabilize load. The addition of a lamp load (resistance load) may compensate partially for load changes caused by intermittent motor operation. Do not overload.
Loose terminal or load connections.	Make better connection mechanically and electrically.
Defective bearing causing uneven air gap.	Replace worn bearing.

HIGH VOLTAGE:

CAUSE	CHECK AND REMEDY
Excessive speed.	Check engine for malfunction.

OVERHEATING:

CAUSE	CHECK AND REMEDY
Generator overloaded.	Reduce load. (Check with ammeter and compare with nameplate rating.)
Clogging ventilating screens.	Clean air passages.
High room temperature	Improve ventilation.
Insufficient circulation.	Provide cross-ventilation.
Low power factor.	Reduce inductive loads or install power factor improvement capacitors.
Unbalanced load.	The load on each leg should be as evenly balanced as possible and should not exceed the rated current on any leg.
Dry bearing.	Replace bearing.

MECHANICAL NOISE:

CAUSE	CHECK AND REMEDY
Defective bearing.	Replace bearing.
Rotor scrubbing on stator.	Bad bearing, replace. Bent shaft, return to factory. Loose endbell, tighten; loose drive discs, tighten.
Loose laminations.	Return to factor for repair.
Loose or misaligned coupling.	Tighten or align.

GENERATOR FRAME PRODUCES SHOCK WHEN TOUCHED:

CAUSE	CHECK AND REMEDY
Static charge.	Ground generator frame.
Grounded armature or field coil.	Return to factory for repair.

ELECTRICAL WIRING PROCEDURES — WIRING DIAGRAMS

CAUTION

Wiring of the alternator should be done in accordance with good electrical practices. Follow government, association and industry standards. In some wiring arrangements, groups of terminals are connected together with no further termination. These terminals must be properly insulated to avoid a hazard to personnel and potential equipment damage.

Linn MAC alternators are supplied in 10-lead or 12-lead configurations. From the nameplate information and system voltage requirements, select the appropriate wiring diagram from the information that follows.

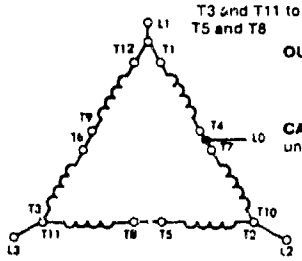
WIRING REFERENCE CHART

	Configuration	MAC Type Specific Voltage (60 HZ)	Ref. Diag.
3 Phase	12-Lead Unit, 4-Wire 240 Volt Delta Connected	240V	A
3 Phase	12-Lead Unit, High Voltage Wye Connected	416V	B
3 Phase	12-Lead Unit, Low Voltage Wye Connected	208V	C
3 Phase	10-Lead Unit, High Voltage Wye Connected	480V	D
3 Phase	10-Lead Unit, Low Voltage Wye Connected	240V	E
1 Phase	12-Lead Unit, Low Voltage Delta	120V	F
1 Phase	12-Lead Unit, 240 Volt Zigzag	240V	G

DIAGRAM A

12-Lead Unit, 240 Volt, Delta Connected, 3 Phase

Connect together the following six sets of terminations:
T1 and T12 to form L1 T2 and T10 to form L2
T3 and T11 to form L3 T4 and T7 to form L0
T5 and T8 T6 and T9



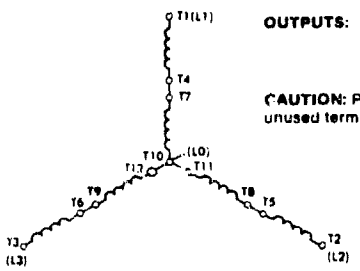
OUTPUTS: 120V, 1Ø: L1 to L0, L2 to L0 — 240V, 3Ø: L1 to L2, L2 to L3, L1 to L3

CAUTION: Properly insulate all unused terminations

DIAGRAM B

12-Lead Unit, High Voltage, Wye Connected, 3 Phase

Connect together the following four sets of terminations:
T4 and T7 T5 and T8 T6 and T9
T10, T11 and T12 to form L0
T1 is L1 T2 is L2 T3 is L3

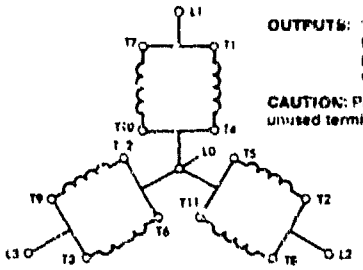


OUTPUTS: 240V, 1Ø: L1 to L0, L2 to L0, L3 to L0 — 416V, 3Ø: L1 to L2, L2 to L3, L1 to L3

CAUTION: Properly insulate all unused terminations.

DIAGRAM C
12-Lead Unit, Low Voltage, Wye Connected, 3 Phase

Connect together the following four sets of terminations:
T1 and T7 to form L1 T2 and T8 to form L2
T3 and T9 to form L3
T4, T5, T6, T10, T11 and T12 to form L0

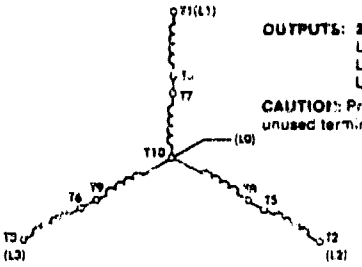


OUTPUTS:	120V, 1Ø	240V, 3Ø
	L1 to L0	L1 to L2
	L2 to L0	L2 to L3
	L3 to L0	L1 to L3

CAUTION: Properly insulate all unused terminations.

DIAGRAM D
10-Lead Unit, High Voltage, Wye Connected, 3 Phase

Connect together the following four sets of terminations:
T4 and T7 T5 and T8 T6 and T9
T1 is L1 T2 is L2 T3 is L3

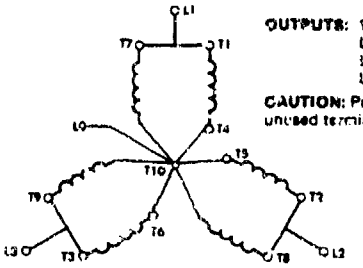


OUTPUTS:	277V, 1Ø	480V, 3Ø
	L1 to L0	L1 to L2
	L2 to L0	L2 to L3
	L3 to L0	L1 to L3

CAUTION: Properly insulate all unused terminations.

DIAGRAM E
10-Lead Unit, Low Voltage, Wye Connected, 3 Phase

Connect together the following four sets of terminations:
T1 and T7 to form L1 T2 and T8 to form L2
T3 and T9 to form L3
T4, T5, T6 and T10 to form L0

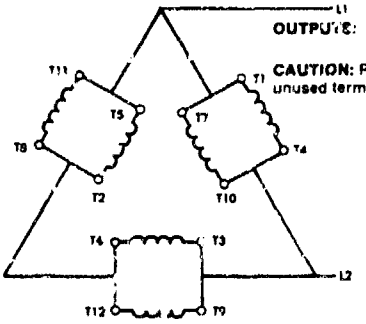


OUTPUTS:	120V, 1Ø	240V, 3Ø
	L1 to L0	L1 to L2
	L2 to L0	L2 to L3
	L3 to L0	L1 to L3

CAUTION: Properly insulate all unused terminations.

DIAGRAM F
12-Lead Unit, Low Voltage, Delta Connected, 1 Phase

Connect together the following three sets of terminations:
T2, T8, T6, T12 and Insulate
T1, T5, T7, T11 to form L1
T3, T4, T9, T10 to form L2

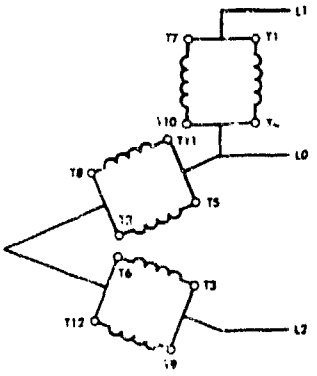


OUTPUTS: 120V, 1Ø
L1 to L2

CAUTION: Properly insulate all unused terminations.

DIAGRAM G
12-Lead Unit, 240 Volt, Zigzag, 1 Phase

Connect together the following four sets of terminations:
T2, T8, T6, T12 and Insulate
T1, T7, to form L1
T3, T9, to form L2
T4, T10, T5, T11 to form L0

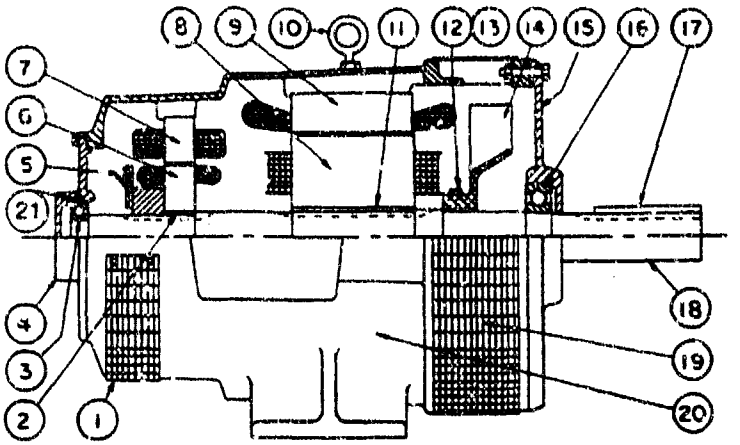


OUTPUTS:	120V, 1Ø	240V, 1Ø
	L1 to L0	L1 to L2
	L2 to L0	

CAUTION: Properly insulate all unused terminations.

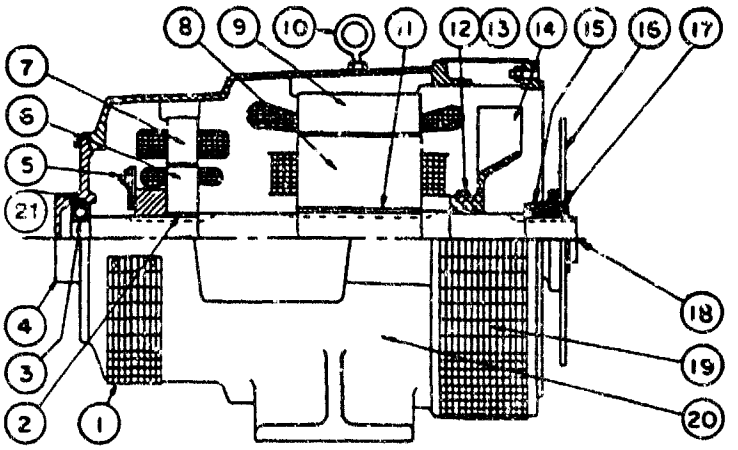
DRIPPROOF GENERATOR PARTS LIST
280 FRAME
TWO BEARING

Part No.	Part Name
1	Screen, Intake
2	Key, Rectifier
3	Bearing
4	Bearing, Cap
5	Rectifier Assembly
6	Exciter Rotor
7	Exciter Stator
8	Generator Rotor
9	Generator Stator
10	Eyebolt
11	Key, Rotor
12	Screw, Hex Hd.
13	Nut, Hex
14	Fan
15	Endplate, Sheave End
16	Bearing
17	Key, Output
18	Shaft
19	Screen
20	Generator Frame
21	O-Ring



DRIPPROOF GENERATOR PARTS LIST
280 FRAME
SINGLE BEARING

Part No.	Part Name
1	Screen, Intake
2	Key, Rectifier
3	Bearing
4	Bearing, Cap
5	Rectifier Assembly
6	Exciter Rotor
7	Exciter Stator
8	Generator Rotor
9	Generator Stator
10	Eyebolt
11	Key, Rotor
12	Screw, Hex Hd.
13	Nut, Hex
14	Fan
15	Hub
16	Drive Discs
17	Key, Output
18	Shaft
19	Screen
20	Generator Frame
21	O-Ring



LIMA TECHNICAL BULLETIN

Irrigation System Alternators

Generator Application Considerations For Electric Center Pivot And Lateral Move Irrigation Systems

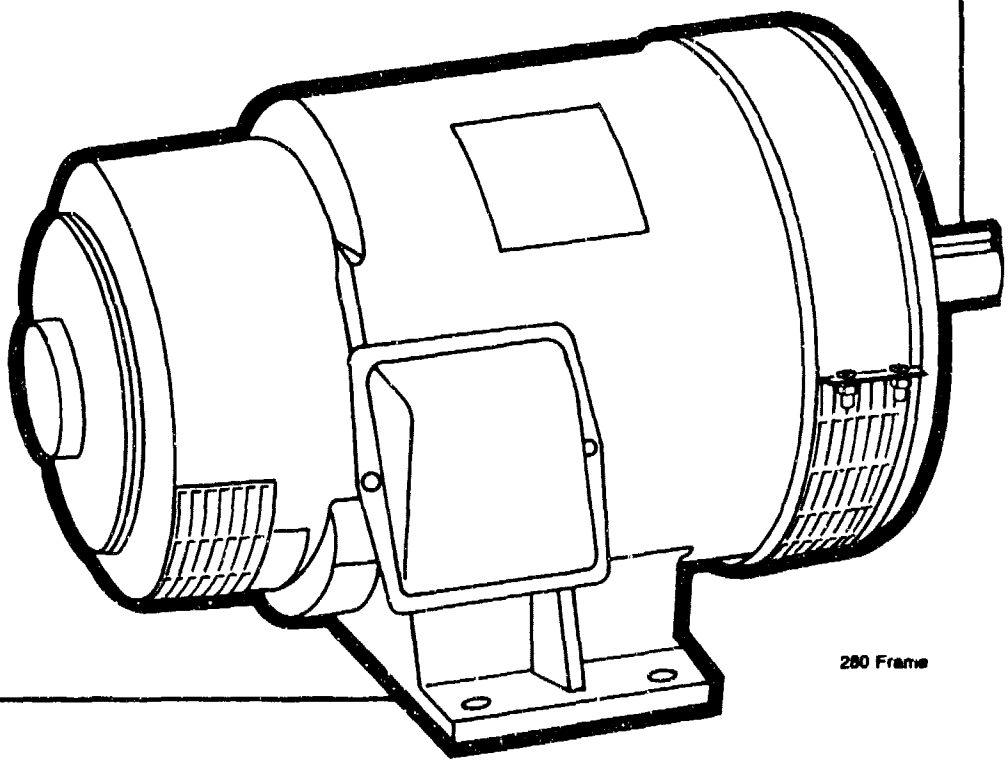
INTRODUCTION

Most center pivot and lateral move irrigation systems are installed in applications where 3 phase utility power is not available or economical. In these applications, electric generators are used to power the 3 phase electric motor that drives the wheels at each irrigation tower.

The primary generator application considerations are:

1. Electric motor starting capacity of the generator
2. Electric motor operating characteristics
3. Ambient temperatures
4. Environmental conditions
5. Maintenance requirements
6. Generator sizing

This paper will address each of these considerations. The observations presented here are supported by the successful performance of the Lima MAC generators on over 30,000 irrigation systems around the world.



280 Frame

1. ELECTRIC MOTOR STARTING CAPABILITY

Typical irrigation systems have from 7 to 20 support towers. There is usually a 3 phase, 480 volt, 60 hertz or 3 phase, 400 volt, 50 hertz electric drive motor at each tower. The electrical control systems continuously turn these motors on and off as required to keep the system in alignment. Thus, the ability of the generator to accomodate the high inrush starting current of the motors is a critical application consideration. The generator design characteristic is usually expressed in motor HP/generator KW electric motor starting capabilities. Thus, a generator with a 1 HP/1 KW characteristic has twice the motor starting capability as another design with a .5 HP/1KW capability.

Most general purpose type generators which utilize external automatic voltage regulators have motor starting capability of approximately .5 HP/ 1 KW.

Special purpose generators such as the patented Lima MAC (Motor Application Characteristic) have a 1 HP/ 1 KW motor starting capability, and are better suited for irrigation system applications. The MAC output voltage dips less than 35% when a 1HP/ 1KW motor load is applied across the line, and smoothly recovers to full voltage in less than one second.

2. ELECTRIC MOTOR OPERATING CHARACTERISTICS

Most irrigation systems use electric drive motors rated 1 HP, 3 phase, 480 volts, 60 hertz, 1800 RPM or 400 volts, 50 hertz, 1500 RPM. The drive motor is connected to a gear reduction system to obtain the proper wheel speed. The drive motors are designed for the extremely high torque starting requirements of the system. The starting amperage requirement of an individual motor is commonly 10-15 times its running amperage. The total irrigation system operates at a low power factor of .5 to .6 because of the inherently low P.F. of each motor running and extremely low P.F. of individual motors when starting. The conservative 80 degree C temperature rise rating of the Lima MAC generator provides extra KVA capacity to handle the low power factor irrigation system loads.

The generator is also rated 3 phase, 480 volts, 60 hertz, 1800 RPM, or 400 volts, 50 hertz, 1500 RPM. The output voltage is controlled by the generator voltage regulation system, but the output frequency is entirely controlled by the speed of the engine driving the generator. If the generator speed varies from rated RPM, the output frequency will go above or below rated frequency. Irrigation applications many times use the pumping engine to pump water plus drive the generator. Thus, engine speed and generator frequency control is not as precise as normal generator applications.

The electric drive motor has a volts/hertz design characteristic. The volts/hertz design characteristic allows the drive motor to be operated under and over rated frequency as long as the voltage changes in direct relation to the change in frequency. To avoid drive motor overheating, the generator output voltage should also have this volts/hertz characteristic.

Most general purpose type generators with an external voltage regulator have constant output voltage regardless of variations in engine speeds. Some voltage regulators have "underfrequency protection" and will reduce the voltage at speeds below rated frequency, but will not increase the voltage at speeds above rated frequency.

The Lima MAC Generator has an inherent volts/hertz characteristic both below and above rated speed and this design feature is especially suited for irrigation systems, avoiding damage to the drive motors.

3. AMBIENT TEMPERATURES

Most modern generators, including the Lima MAC, use Class F insulation materials rated 145 degree C total temperature. The temperature rise of the generator is determined as follows:

145 degree C Total Temperature
– 40 degree C Ambient Temperature
105 degree C Maximum Temperature Rise

This means that in a 40 degree C ambient, the generator cannot exceed 105 degree C rise during operation without experiencing insulation system deterioration. Also, if ambient temperatures above 40 degree C are expected, a generator with less than 105 degree C temperature rise must be selected. For example, if 50 degree C ambients are expected, the generator temperature rise should be limited to a maximum 95 degree C temperature rise.

Most generators designed to British standards are rated 100 degree C rise. Most continuous duty generators designed to NEMA standards have 105 degree C rise ratings.

The Lima MAC Irrigation Generators are rated at a conservative 80 degree C rise and are well suited for irrigation system applications in areas where 50 degree C ambients are experienced.

4. ENVIRONMENTAL CONDITIONS

Most irrigation system generators are installed outdoors in unprotected areas. Thus, they are subject to blowing sand and dirt, water, and agriculture chemicals. For maximum generator life with minimum maintenance, a simple, reliable, basic design is desired.

Generator designs which utilize brushes and slip rings should be avoided. Generators which have complicated electronic voltage regulators, fragile printed circuit boards, contactors, sliding resistors, and complicated wiring of external current transformers are prone to numerous maintenance problems and poor reliability.

The Lima MAC has an extremely simple rotating current transformer exciter, is brushless, self-regulated, and does not utilize an external automatic voltage regulator. The weather protected Type I construction, double sealed bearings, and moisture resistant electrical insulation system provides long life on irrigation system applications.

5. MAINTENANCE REQUIREMENTS

As in any sophisticated system, minimum maintenance is a key design objective. More often, less complicated designs result in minimum maintenance because of their simplicity, fewer parts, etc.

Following is a comparison of the Lima MAC and other general purpose generator designs from a maintenance viewpoint:

	Lima MAC Generator	Typical General Purpose Generator
Bearings	Oversized - Permanently Lubed Simple Outboard Location	Perm. Lubed or Greaseable Complicated Inboard Design
Full Wave 3 Phase, Rotating Rectifier Assy.	Yes	Some only half wave
Slip Rings, Brushes	None	No or Yes
External Volt. Regulator	None	Yes
Switches, Knobs, Resistors For Output Control	None	Yes

The simplicity of the Lima MAC design has proven to be the minimum maintenance design for irrigation systems

6. GENERATOR SIZING

Because of the 1 HP/1KW motor starting capability of the MAC, sizing the generator to the irrigation system is simple.

a. STANDARD IRRIGATION SYSTEM:
Number of irrigation system towers $\leq$
KW rating of Lima MAC Generator

b. IRRIGATION SYSTEM WITH ELECTRIC BOOSTER PUMP:
Number of irrigation system towers
+ HP rating of booster motor $\leq$
KW rating of Lima MAC generator.

Number of Towers	+	Booster Motor HP	Lima MAC Generator Rating
7	+	0	7½ KW
7	+	3 HP	10 KW
10	+	0	10 KW
10	+	3 HP	15 KW
12	+	0	12 KW
15	+	5 HP	20 KW

If a larger than required (oversized) Lima MAC Generator is used to power the irrigation system, the power demanded by the irrigation system does not change. The Lima MAC Generator only supplies the power demanded by the electrical load.

"Oversized" Lima MAC Generators operate cooler than normal, increasing overall life expectancy. Also, an oversized alternator may allow for the addition of an electric booster pump at a later date, incorporating the original generator.

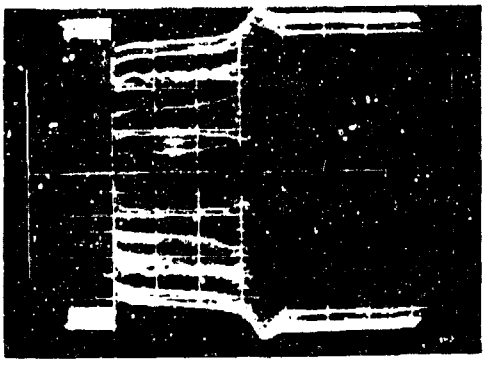
The decision of using "oversized" Lima MAC Generators is typically made based on an evaluation of first cost, interchangeability of generators between irrigation systems, inventory costs, and future electrical requirements (increasing system length/addition of booster pump).

In summary, the Lima MAC Generator is the SIMPLIST, most RELIABLE, and most ECONOMICAL generator available for pivot and lateral move irrigation system.

SPECIFY LIMA MAC...YOUR PRODUCTIVITY DEPENDS ON IT!!

Patented Recovery Circuit

This oscillograph shows the recovery capability of the MAC's patented voltage control circuitry. With a 1 HP per KW motor load applied across the line, voltage dip is under 35%, followed by a smooth recovery to full voltage in less than one second.



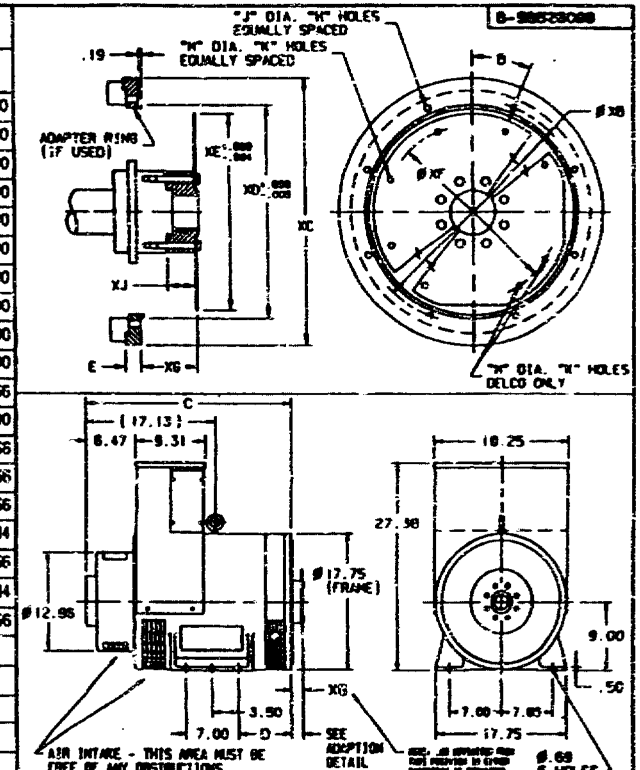
LIMA Lima Energy Products

The Lima Electric Co., Inc.
P.O. Box 918
Lima, Ohio 45802
(419) 227-7327
TELEX 242433

Making Energy Work For You

71983 Printed in U.S.A.

MTG CODE	ADAPTER SAE SIZE	H	J	XB	XC	XD	E	B	DRIVE DISC SAE SIZE	K	M	XE	XF	XG	XJ	C	D
I	•5	8	.42	13.12	17.75	12.375	1.00	22 1/2°	•6 1/2	6	.34	8.499	7.88	1.19	.62	28.12	8.00
O	•5	8	.42	13.12	17.75	12.375	1.00	22 1/2°	•7 1/2	8	.34	9.499	8.75	1.19	.62	28.12	8.00
R	•5	8	.42	13.12	17.75	12.375	1.00	22 1/2°	•8	6	.41	10.374	9.62	2.44	1.88	28.12	8.00
T	•5	8	.42	13.12	17.75	12.375	1.00	22 1/2°	•10	8	.41	12.374	11.62	2.12	1.56	28.12	8.00
V	•4	12	.42	15.00	17.75	14.250	1.00	15°	•6 1/2	6	.34	8.499	7.88	1.19	.62	28.12	8.00
G	•4	12	.42	15.00	17.75	14.250	1.00	15°	•7 1/2	8	.34	9.499	8.75	1.19	.62	28.12	8.00
C	•4	12	.42	15.00	17.75	14.250	1.00	15°	•8	6	.41	10.374	9.62	2.44	1.88	28.12	8.00
Y	•4	12	.42	15.00	17.75	14.250	1.00	15°	•10	8	.41	12.374	11.62	2.12	1.56	28.12	6.30
X	•3	12	.42	16.88	17.75	16.125	-	15°	•8	6	.41	10.374	9.62	2.44	.88	27.12	7.00
D	•3	12	.42	16.88	17.75	16.125	-	15°	•10	8	.41	12.374	11.62	2.12	.56	27.12	7.00
Z	•3	12	.42	16.88	17.62	16.125	1.56	15°	DELCO 12.75	4	.53	12.749	11.30	0.00	0.00	28.69	8.56
A	•3	12	.42	16.88	17.75	16.125	-	15°	•11 1/2	8	.41	13.874	13.12	1.56	0.00	27.12	7.00
O	•2	12	.42	18.38	19.25	17.625	.56	15°	•8	6	.41	10.374	9.62	2.44	1.44	27.65	7.56
K	•2	12	.42	18.38	19.25	17.625	.56	15°	•10	8	.41	12.374	11.62	2.12	1.12	27.69	7.56
B	•2	12	.42	18.38	19.25	17.625	.56	15°	•11 1/2	8	.41	13.874	13.12	1.56	.56	27.69	7.56
N	•2	12	.42	18.38	19.25	17.625	.84	15°	DELCO 15.50	8	.66	15.499	13.88	.72	0.00	27.97	7.84
E	•1	12	.49	20.88	21.75	20.125	.56	15°	•11 1/2	8	.41	13.874	13.12	1.56	.56	27.69	7.56
H	•1	12	.48	20.88	21.75	20.125	.84	15°	DELCO 17.75	8	.66	17.749	15.50	.72	0.00	27.97	7.84
F	•1	12	.48	20.88	21.75	20.125	.56	15°	•14	8	.53	18.374	17.25	1.00	0.00	27.69	7.56



MASTER COPY

REV	DATE	CHANGE	
3	1-21-88	PART NAME WAS 380 FR. SER 1 BRG.	TM
2	1-21-88	XB DIM. FOR CODE "D" WAS 1.56, ADD (17.13) LIFTLUG LOC. & .56 DEVIATION NOTE CN 05712	TM
1	7-22-88	NEW DRAWING	PR

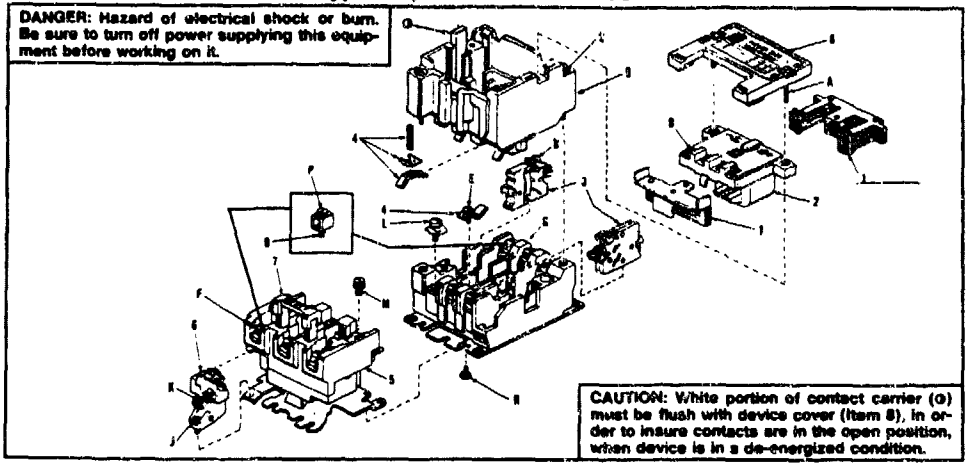
MARATHON ELECTRIC
WAUSAU, WISCONSIN 54401
DRAWN BY PR 7-19-88
APPD PJS 7-22-88
PART NAME OUTLINE 380-381 FR. SER 6 MAC 1 BRG.
B-SS526059

CONTROL PANEL

8502/36-278
SERVICE BULLETIN

Classes 8502 and 8536 Sizes 1 and 1P — AC Magnetic Contactors and Starters Type SC, Series A or Series B

DANGER: Hazard of electrical shock or burn. Be sure to turn off power supplying this equipment before working on it.



CAUTION: White portion of contact carrier (G) must be flush with device cover (Item 8), in order to insure contacts are in the open position, when device is in a de-energized condition.

SERIES CHANGE — Series B only applies to the Type S Starter Form B (3 ambient compensated overloads). All parts of Form B Series A and B starters are interchangeable; only the overload relay block differs. If the overload relay block of a Form B Series A starter is replaced with the Series B block, the overload relay thermal units must be selected from the Series B thermal unit selection tables for proper motor protection.

● **ACCESSORIES** — Auxiliary contacts, power pole kits and other field addable kits are available. Refer to the Square D Digest Class 9999 section for selection and application information.

● **OVERLOAD RELAYS** — Melting alloy overload relay blocks are supplied as standard with provisions for 1, 2 or 3 thermal units. The 2 thermal unit melting alloy overload block can be converted to a 3 thermal unit block by removing the center strap and installing a thermal unit in its place. The contact unit (Item 6) of the melting alloy overload block can be supplied with a N.O. or N.C. isolated alarm circuit contact in addition to the standard N.C. contact. The alarm circuit contact unit can be installed in the field. See Parts List.

Bimetallic overload relays are available as an optional feature. Starters with Form B1 (provisions for 2 thermal units) and Form B2 (provisions for 3 thermal units) use a non-compensated overload relay block. Form E starters (provisions for 3 thermal units) are supplied with an ambient temperature compensated overload relay block.

A SPDT contact is supplied as standard on all Type S bimetallic overload relays. The N.O. contact can be used in an alarm circuit and must be wired on the same polarity as the N.C. contact. Contacts are not replaceable. In order to directly replace a bimetallic overload relay, the appropriate part number listed on the Parts List should be used.

TERMINALS — Power and control terminals on standard devices are suitable for use with **copper wire only.**

CONTACTS — Are not harmed by discoloration and slight pitting. DO NOT FILE THEM as dressing wastes contact material. Replacement is necessary only when the contact has worn thin.

CONTACT INSPECTION — It is unnecessary to remove any wiring to inspect contacts. Merely loosen the two captive screws (Item C) which hold the contact actuator to the contact block. Lift the contact actuator to expose contacts.

● **MECHANICALLY INTERLOCKED UNITS** — Refer to Service Bulletin 9999-286 for mechanical interlock.

● **REPLACEMENT CONTACTS** — Replacement power contacts and springs for starters or contactors are available as kits. Order from Parts List.

Replacement contacts and springs for the **power pole kits only** are contained in a Class 9998 Type SL-22 Kit. One kit is required for each N.O. or N.C. contact.

MANUAL OPERATION — Manual operation of contactors and starters may be accomplished by pushing the contact carrier down with a screwdriver. A slot is provided in the contactor cover for this use. **DANGER** — Do not manually operate unless starter is isolated from the line.

COIL REPLACEMENT — To replace the coil loosen the two captive cover screws (Item A) and remove the cover. Disconnect wires from coil terminals. Remove the coil and magnet assembly. Separate the coil from the magnet assembly.

Reassembly is a reversal of the above. Manually operate (See Manual Operation, above) the device when reassembled to insure all parts are functioning properly. Follow recommended tightening torques when reassembling device.

● **ASSEMBLY INSTRUCTIONS** — Factory recommended torques for mechanical, electrical and pressure wire connections are listed in the Recommended Tightening Torque Table and Instruction Sheet. These must be followed to insure proper functioning of the device.

SHORT CIRCUIT PROTECTION — Branch-circuit overcurrent protection must be provided for each contactor or starter. For starters, refer to instructions furnished with the thermal unit selection table. For contactors (Class 8502 or 8702), provide branch-circuit overcurrent protection in accordance with the National Electrical Code, except do not exceed the maximum protective device ratings listed below.

NEMA Size	Maximum Voltage	Time Delay Fuse (Ampere)	Non-Time Delay Fuse (Ampere)	Inverse-Time Circuit Breaker (Ampere)
1	600 250	30 40	60 60	40 60

Supersedes 278A5 dated April, 1985

● Revised

June, 1988

SQUARE D
P.O. Box 27446
Raleigh, N.C. 27611
(919) 266-3671

8502/36-278
SERVICE BULLETIN

DISTANT CONTROL OF CONTACTORS & STARTERS — To assure proper contactor operation, series impedance and shunt capacitance of the control circuit must be considered. Depending upon the voltage, wire size, and the number of control wires used, the limiting factor for figuring the maximum distance of the wire run may be series impedance or shunt capacitance. If distances to start or stop stations are longer than those listed, the wire run configuration and materials must be analyzed. For further information contact your local Square D field office and ask for Product Data Bulletin M379.

Coil Voltage (60 Hz)	Minimum Control Distance (in feet)	
	#14 Copper Wire	#12 Copper Wire
120	845	1300
240	585	466
480	145	120

ORDERING INSTRUCTIONS — Specify quantity, part number and description of part, giving complete nameplate data of the device. For example, one Armature and Magnet Kit 31041-605-50 for Class 8536 Type SCO-3, Series A starter .

PARTS LIST

Item	Description	Part Number	Quantity				
			1 Pole	2 Pole	3 Pole	4 Pole	5 Pole
1	Armature and Magnet Kit	31041-605-50	1	1	1	1	1
2	Coil	See Table Below	1	1	1	1	1
3	Internal Holding Circuit Contact	Class 9998					
	Normally Open	Type SX-11	•	•	1	1	1
	Normally Closed	Type SX-12	....	....	....	....	....
4	Contact Kit	Class 9998					
		Type SL-3	1	1	1	....	....
		Type SL-13	....	....	....	1	....
		Type SL-13 and SL-22	....	....	....	....	1
5	Melting Alloy O.L. Relay Assembly	Class 9065					
	1 Element	Type SDO-4	1	1	....	....	....
	2 or 3 Element	Type SDO-5	....	....	1	1	1
†5	Bimetallic O.L. Relay						
	Non Compensated	Class 9065					
	2 Element (Form B1)	Type SDO-581	....	....	....	....	....
	3 Element (Form B2)	Type SDO-582	....	....	....	....	....
	Compensated	Class 9065					
	3 Element (Form B)	Type SDO-68	....	....	....	....	....
3	Melting Alloy O.L. Contact Unit	Class 9998 Type SO-1	1	1	1	1	1
●T5	Melting Alloy O.L. Contact Unit with Alarm Circuit						
	Normally Open Alarm Contact	Class 9998 Type SO-4					
	Normally Closed Alarm Contact	Class 9999 Type SO-5					
7	Reset Bar	31034-042-01	1	1	1	1	1
8	Cover	31127-013-01	1	1	1	1	1
9	Actuator Assembly (Housing, Bellcrank, Bearings, Contact Carrier, Cover)	31041-011-52	....	1	1	....	....
†	Power Pole Kit	Class 9999					
	One Normally Open	Type SB-6	....	....	....	1	....
	Two Normally Open	Type SB-9	....	....	....	....	1
F	Wire Clamp and Screw						
	Size 1 Contactor	30018-018-50	....	....	....	2	4
	Size 1 Starter	30018-018-50	....	2	3	5	7
L	Wire Clamp and Screw						
	Size 1 Contactor	48118-247-50	2	4	6	8	6
	Size 1 Starter	48118-247-50	....	4	6	8	8
M	Overload Thermal Unit Fastening Screw	21820-19180	....	4	6	8	8
●O	Screw Assembly	30018-066-50	4	....	....	....	....
●P	Screw Lug	25054-13600	....	4	....	....	....

† Not Shown.
• Furnished on 2 pole starters. However, 1 and 2 pole contactors are furnished with a holding circuit contact that is rated the same as a power pole.
● Size 1P only.

FACTORY RECOMMENDED TIGHTENING TORQUES

Item	Description	Tightening Torque (lb-in)
A	Cover Screws (2 per cover)	18-21
●B	Coil Terminal Pressure Wire Connector (2 per coil)	9-12
C	Power Plate Screws (2 per device)	18-21
●D	Internal Housing Circuit Contact Pressure Wire Connector (2 per contact)	9-12
E	Retainery Contact Fasteners (2 per pole)	6-9
F	Screw Lug (2 per pole)	♦
●G	Auxiliary Wire Binding Screws	18-21
H	Overload Relay Fastening Screw (2 per overload block)	18-21
J	Overload Switch Module Fastening Screw (1 per module)	9-12
●K	Switch Module Pressure Wire Connectors (standard is 2 per module, with alarm circuit contact there are 4)	9-12
L	Overload to Contactor Fasteners (3 per device, except 2 on 2 pole starters)	18-21 ▲
M	Overload Thermal Unit Fastening Screw (3 per pole)	18-21
O	Lug Retaining Screw — Size 1P Only (1 per pole)	18-21

♦ See Instruction Sheet
▲ For contactor, see Instruction Sheet

MAGNET COILS●

Coil Prefix	Hertz	COIL SUFFIX													
		24 Volts	110 Volts	120 Volts	120/240 Volts	208 Volts	220 Volts	240 Volts	240/480 Volts	277 Volts	380 Volts	440 Volts	480 Volts	550 Volts	600 Volts
●● 31041-400-	60	20	Use 120 Volt	42	‡	48	Use 240 Volt	51	‡	52	56	Use 480 Volt	60	Use 600 Volt	62
	50	22	42	43			51	53			57	60		62	64

● When ordering replacement coils, give part number, voltage and frequency of coil being replaced.
●● Complete part number of coil consists of the prefix followed by the suffix. (Example: For 120 Volt, 60 Hertz coil, select a 31041-400-42)
‡ Dual Voltage coil. Order 120/240 volt, 60 Hertz, as 31041-402-02. Order 240/480 volt, 60 Hertz, as 31041-402-04

●Revised

Supersedes 278AS dated April, 1985

SQUARE D
P.O. Box 27446
Raleigh, N.C. 27611
(919) 266-3671

PRINTED IN U.S.A.

502 AS
SERVICE BULLETIN

30 Ampere Disconnect Switches with Flange Mounted Operating Mechanism Used in Classes 8538 and 8738 — Type SB Series C Size 0 and Type SC Series C Size 1 3-Pole AC Combination Starters

WARNING: Be sure to open the back-up disconnect device ahead of the combination starter before inspecting or servicing the disconnect switch. Do not operate starter or disconnect switch with arc chamber cover or arc suppressor removed.

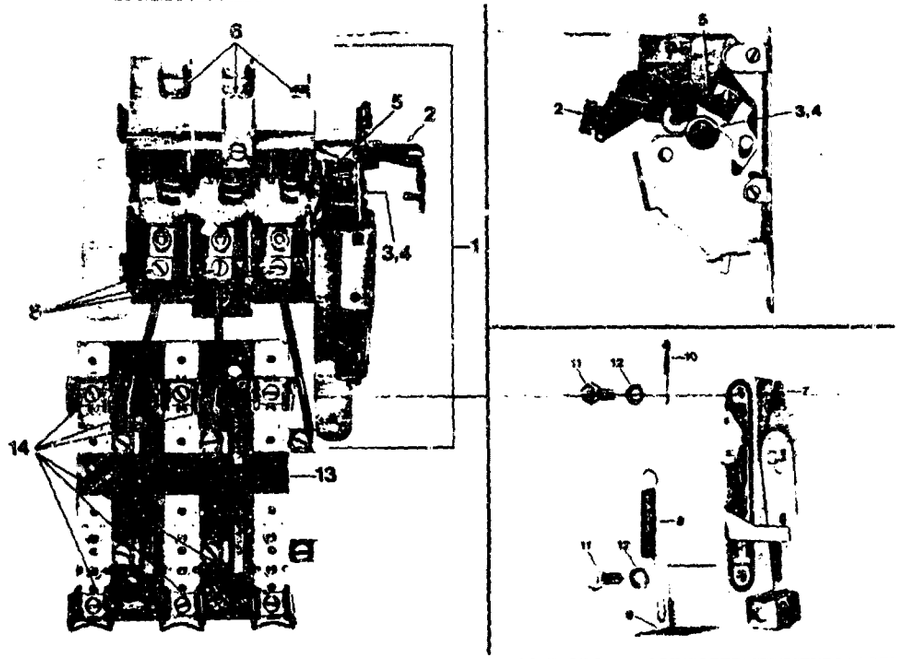


TABLE I PARTS LIST

Item No.	Description	Part Number	Quantity Required
1	Complete Disconnect Switch Assembly with operating mechanism — includes items 2-6	31301-014-52	1
2	Link Assembly	31301-012-50	1
3	Washer	31301-006-01	2
4	E-Ring	29807-016-10	1
5	Spring	31301-010-01	1
6	Lug	25065-03800	6
7	Handle Assembly		
	For NEMA Type 1 or 12 enclosure	31055-229-51	1
	For NEMA Type 4 enclosure	31055-229-52	1
8	Return Spring	30017-143-01	1
9	Spring Holder	31055-249-01	1
10	Cotter Pin	24201-08400	1
11	Hex Head Cap Screw	21401-20200	2
12	Lock Washer	23701-00200	2
13	Fuse Block	9999 SF-1	1
14	Fuse Clips	See Table 2	

SQUARE D COMPANY
P.O. Box 472
Milwaukee, Wis. 53201
(414) 332-3000

502 AS
SERVICE BULLETIN

TABLE 2 FUSE CLIP KITS‡ — For use with 30 Ampere Disconnect Switch								
	INTERCHANGEABLE					NON-INTERCHANGEABLE		
	Class H Fuses			Class J Fuses		Class R Fuses⊕		
NEMA Starter Size	Fuse Clip Rating — Amps. 250 V. Max.	600 V. Max.	Class 9999 Type	Fuse Clip Rating — Amps. 600 V. Max.	Class 9999 Type	Fuse Clip Rating — Amps. 250 V. Max.	600 V. Max.	Class 9999 Type
0 & 1	0-30	...	S-1	...	...	0-30	...	SR-1
0	...	0-30	S-2	0-30	SJ-2	...	0-30	SR-2
1	31-60	0-30	S-2	0-30	SJ-2	31-60	0-30	SR-2

‡ Each kit includes six fuse clips, mounting hardware, and instruction sheet.
⊕ Clips cannot be removed, once installed.

ELECTRICAL INTERLOCK

A one or two pole electrical interlock kit may be added to the switch operating mechanism. The snap switch in the interlock kit may be replaced on existing installations. See table 3.

TABLE 3

Electrical Interlock Type	Electrical Interlock Mechanism Complete		Replacement Snap Switch Only	
	Class	Type	Class	Type
Single pole	9999	R45	9007	AO-1
Double pole	9999	R46	9007	CO-3

ORDERING INSTRUCTIONS

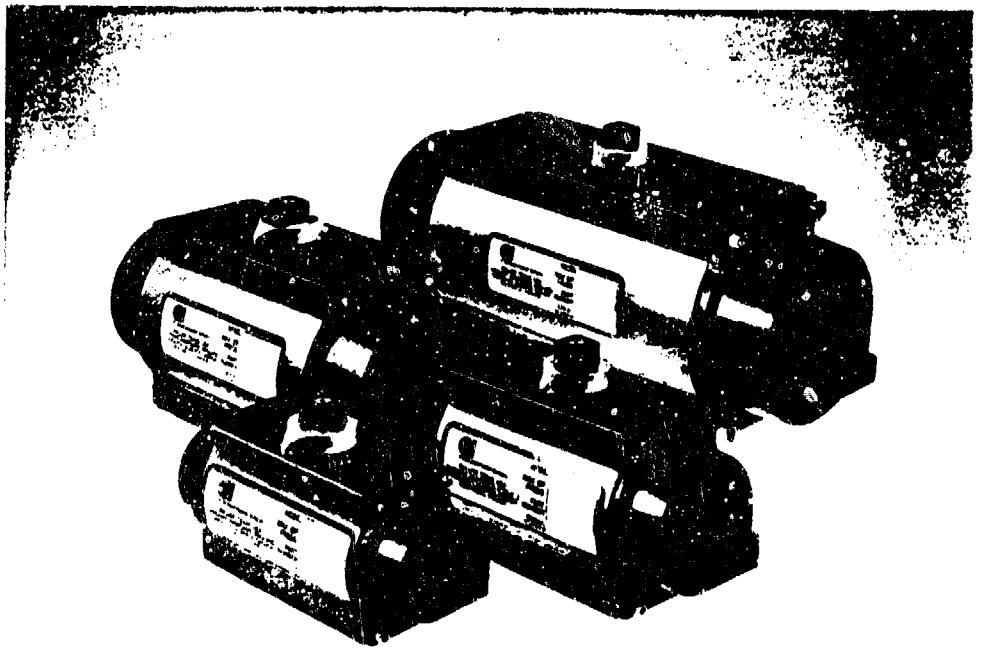
Specify quantity, part number and description of part.

SQUARE D COMPANY
P.O. Box 472
Milwaukee, Wis. 53201
(414) 332-2000

PNEUMATIC ACTUATORS

A Galveston-Houston Company

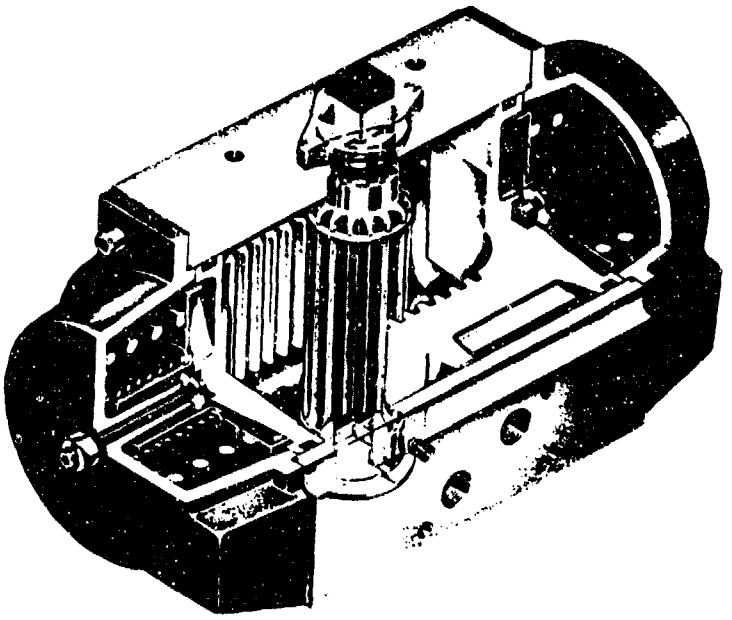
RPB-Series Pneumatic Actuators



Flow-Tech, Inc.
4751-P Hugh[illegible] Tucker, Georgia 30084
Tel: 404/939-9[illegible]

Design and Construction

Models RPB250-RPB2250

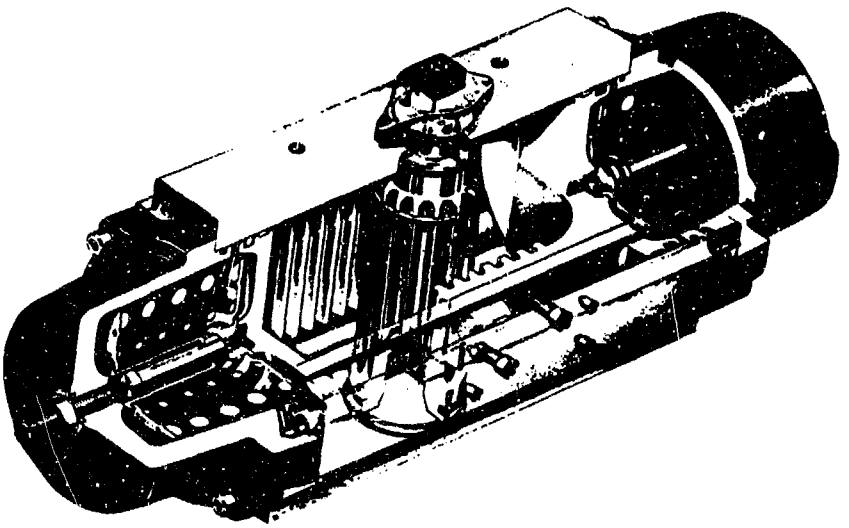


Mechanical Components

The Bettis RPB-Series pneumatic rack & pinion actuators are specifically designed for "quarter-turn" rotating mechanisms and are ideally suited for operation of plug, butterfly, or ball valves. These quality constructed and uncomplicated actuators provide a dependable, reliable and economic method of opening and closing a valve.

Double-acting models, requiring pressure to rotate in both directions, are available with output torques to 16,500 lb-in. Spring-return models, requiring pressure to rotate in one direction, are available with spring ending output torques up to 5150 lb-in. Standard operating pressures are 40 to 120 PSIG . Operating media for both double-acting and spring-return models may be dry or lubricated non-corrosive gas. Standard operating temperatures are from −40° to +200° Fahrenheit. Optional, high temperature trim is available for 0° to +350° Fahrenheit. All models are factory lubricated for the optimum cycle life of the actuator. All actuators are constructed for indoor or outdoor installation.

Models: RPB5000-RPB11000



Features

1. Bottom loaded, one piece blow-out proof output shaft, is retained by a safety redundant internal retaining ring.

2. Self-contained space saving spring modules allow safe and simple conversion from double-acting to spring-return or to a different spring configuration.

3. Integral position stops allow up to ±5 degrees field adjustment at the 90 degree position.

4. The highly visible position indicator may be indexed 90 degrees as appropriate for optional mounting configurations.

An exposed square male drive suitable for manual override or accessory drive purposes may be removed along with the position indicator to expose the low profile slot-type accessory drive.

5. All fasteners are stainless steel.

6. Square female drive allows direct mount capability for a "low profile" valve actuator assembly.

7. Advanced UV resistant fluoropolymer impregnation of internal and external housing surfaces plus fluoropolymer coating on output drive shaft and end caps provides excellent hostile environment protection.

Materials of Construction

A. Body: Precision-extruded aluminum alloy, hard anodized and fluoropolymer impregnated.

B. Pistons: Cast aluminum alloy, dichromate dipped.

C. Output Shaft/Pinion: Carbon steel, fluoropolymer coated.

D. End Caps: Cast aluminum alloy, fluoropolymer coated.

E. Fasteners: All stainless steel.

F. Seals: Nitrile standard. Viton, optional.

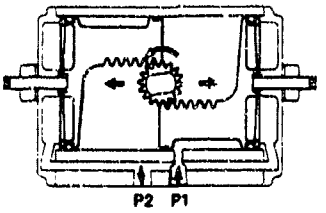
G. Springs: Carbon steel, phosphate coated, oil dipped.

H. Heel Bearing: PEEK Alloy.

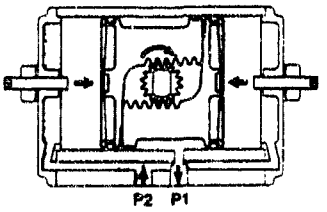
J. Piston Bearing: Fluoroplastic.

Operation

Double-acting
(TOP VIEW)



For counterclockwise output rotation, apply pressure to Port 1, which will force the pistons apart. The linear travel of the pistons is converted to a rotation of the drive shaft by the rack to pinion connection. The volume outside each piston is exhausted at Port 2.

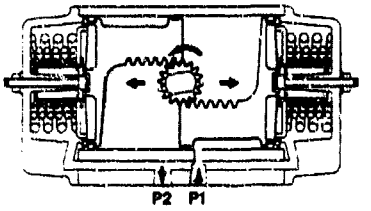


For clockwise output rotation, apply pressure to Port 2, which will force the pistons to move together. The volume between the pistons is exhausted at Port 1.

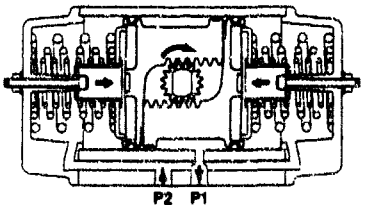
Reverse Rotation

When required, the pistons can be inverted in the housing resulting in a clockwise rotation when pressure is applied to Port 1.

Spring Return
(TOP VIEW)



For counterclockwise output rotation, apply pressure to Port 1, which will force the pistons apart and compress the springs. The linear travel of the pistons is converted to a rotation of the drive shaft by the rack to pinion connection. The volume outside each piston is exhausted at Port 2.



For clockwise output rotation, the volume between the pistons is exhausted at Port 1, causing the springs to force the pistons together. The volume outside the pistons is vented at Port 2.

Reverse Rotation

When required, the pistons can be inverted in the housing resulting in a clockwise rotation when pressure is applied to Port 1 and a counterclockwise rotation when Port 1 is vented.

Travel Stop Adjustment

Drive shaft rotation is limited to 90° plus or minus 5° by the stop screws located in each end cap which limit the pistons outward travel.

Standard Assembly

Adjustment of the counterclockwise rotation limit is accomplished by rotating the stop screws to reduce or increase output rotation.

Reverse Assembly

When required, the pistons can be inverted in the housing allowing travel stop adjustment of the clockwise output rotation.

Typical Specifications

The following information may be used as a guide to compile specifications for rack and pinion pneumatic actuators. GH-Bettis RPB-Series actuators meet, or exceed all the specifications stated below.

1.0 Bettis RPB-Series Pneumatic Rack & Pinion Actuators

1.1 The pneumatic actuator shall be quarter-turn, opposed piston rack and pinion type of a totally enclosed design with no external moving linkages.

1.2 The actuator shall be capable of 95½° rotation and shall include external travel stops with a minimum of 10° adjustment.

1.3 The actuator shall be rated for continuous operation using dry or lubricated non-corrosive gas and suitable for mounting in any position.

1.4 Ambient temperature range shall be from −40°F to +200°F. For high temperature service, the actuator shall be rated from 0°F to +350°F.

2.0 Construction

2.1 Actuator housing shall be precision extruded aluminum, hard anodized with external and internal UV resistant fluoropolymer impregnation.

2.2 Actuator shall be supplied with all stainless steel fasteners.

2.3 The drive shaft and pinion shall be one piece steel, bottom loaded blowout-proof with a fluoropolymer coating and secured by non-exposed, redundant stainless steel retaining rings for safety.

2.4 End caps shall be cast aluminum UV resistant fluoropolymer coated.

2.5 Actuator shall incorporate internal porting to permit use of either direct mount or remote controls with a minimum of external tubing.

2.6 Actuator shall be provided with a mechanical indexable visual position indicator. An optional slot for direct, low profile of shaft driven accessories utilizing unidrive hardware shall be provided.

3.0. Design

3.1 Double-acting and spring-return models shall be offered and field convertible by only the replacement of end caps or spring module assemblies.

3.2 All spring module assemblies must be of self contained field service safe design.

3.3 Spring design shall allow safe conversion of spring modules to fit application requirements.

3.4 Special tools shall not be required to adjust or accomplish field conversions.

3.5 There shall be no bearing area outboard of the pressure containing or weather seals.

3.6 Use of self-threading or thread forming fasteners shall be strictly prohibited.

3.7 Actuator must not incorporate any metal-to-metal pressure seals.

3.8 All springs must be shot peened and corrosion protected to ensure maximum cycle life.

3.9 Actuator shall be field reversible to provide ±5° travel adjustment at outboard end of travel and non-adjustable ½° nominal over travel in opposite direction.

3.10 Full tooth engagement, at the pitch line, shall be maintained throughout full range of travel minimizing potential tooth failure.

Materials of Construction

A. Body: Precision-extruded aluminum alloy, hard anodized and fluoropolymer impregnated.

B. Pistons: Cast aluminum alloy, dichromate dipped.

C. Output Shaft/Pinion: Carbon steel, fluoropolymer coated.

D. End Caps: Cast aluminum alloy, fluoropolymer coated.

E. Fasteners: All stainless steel.

F. Seals: Nitrile standard. Viton, optional.

G. Springs: Carbon steel, phosphate coated, oil dipped.

H. Heel Bearing: PEEK Alloy.

J. Piston Bearing: Fluoroplastic.

Sizing Information

The following information is designed to aid in correctly selecting GH-Bettis Rack and Pinion Actuators.

Accurate valve torques must be determined at extreme and intermediate valve positions. Valve size and type are determined by application requirements, such as differential pressure, media, temperature and valve manufacturers suggested safety factor, that affect required torque at specific valve positions and direction of travel.

For Double-Acting

Using the minimum operating pressure available at the actuator's installed location, select a column from the Torque Rating Chart of less than or equal pressure. Look down the column until an output torque is selected which is greater than the valve's maximum operating requirement. Determine the correct actuator model number which appears on the same line as the selected output torque.

For Spring-Return

The valve's maximum torque requirement at specific locations and direction of travel must be exceeded by the actuator's spring start, end, air start, and end as appropriate.

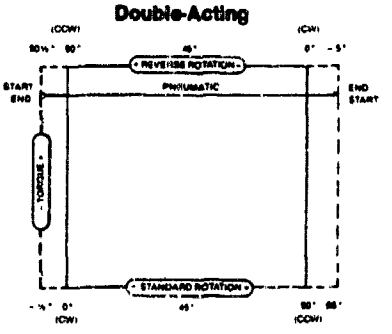
On-Off Fail-Closed Applications

1. Select appropriate actuator spring end and air start torque for maximum valve seating and break torque requirements respectively.
2. Select spring start and air end torque for maximum valve torque requirement at full open position.
3. Compare spring start torque to maximum valve stem allowable torque.

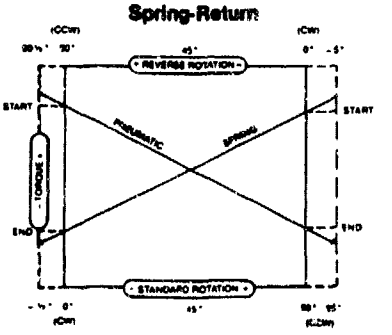
On-Off Fail-Open Applications

1. Select appropriate actuator spring start and air end torque for maximum valve break and seating torque requirement respectively.
2. Select spring end and air start torque for maximum valve torque requirement at full open position.
3. Compare air start torque to maximum stem allowable torque. For modulating and other severe service applications, a minimum actuator torque of 25% greater than the valve torque requirement at all positions of travel is recommended.

Double-Acting



Spring-Return



Torque Ratings (Pound/Inches)

Double-Acting Actuators

RPB	Air Torque Output at Operating Pressure—PSIG					
	Torque Unit	40	60	80	100	120
250	lb.-in.	125	187	250	312	375
450	lb.-in.	225	337	450	562	675
1000	lb.-in.	500	750	1000	1250	1500
2250	lb.-in.	1125	1687	2250	2812	3375
5000	lb.-in.	2500	3750	5000	6250	7500
11000	lb.-in.	5500	8250	11000	13750	16500

Torque Ratings (Pound/Inches)

Spring Return Actuators
RPB-Series (Pneumatic)

Model Number		Spring Torque Output		Air Torque Output at Operating Pressure—PSIG									
				40		60		80		100		120	
RPB	Spring Set	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
250	2	69	45	76	47	138	109	201	172	263	234	326	312
	3	104	67	–	–	113	70	176	133	229	195	301	258
	4	140	90	–	–	88	31	151	93	213	156	276	215
	5	175	112	–	–	–	–	126	54	189	116	251	179
	6	209	135	–	–	–	–	–	–	164	77	227	139
450	2	126	81	135	82	248	196	361	309	473	421	586	533
	3	190	121	–	–	203	125	316	238	428	350	541	463
	4	254	162	–	–	158	54	271	167	383	279	496	392
	5	317	202	–	–	–	–	226	96	339	209	451	321
	6	381	243	–	–	–	–	–	–	293	137	406	251
1000	2	279	179	300	184	549	433	798	682	1 048	931	1 297	1 181
	3	418	270	202	48	449	278	698	526	947	775	1 196	1 025
	4	559	360	–	–	350	120	599	371	848	618	1 097	867
	5	698	450	–	–	–	–	500	212	749	464	998	710
	6	839	540	–	–	–	–	–	–	650	304	899	567
2250	2	659	394	690	395	1 253	958	1 816	1 521	2 379	2 084	2 939	2 647
	3	990	590	–	–	1 034	591	1 596	1 154	2 159	1 717	2 722	2 280
	4	1 320	787	–	–	816	226	1 379	788	2 029	1 351	2 905	1 914
	5	1 650	984	–	–	–	–	1 161	424	1 724	984	2 287	1 549
	6	1 980	1 181	–	–	–	–	–	–	1 506	621	2 069	1 181
5000	2	1 560	785	1 590	803	2 780	1 990	3 970	3 180	5 160	4 380	6 350	5 570
	3	2 340	1 180	–	–	2 380	1 200	3 570	2 400	4 760	3 590	5 960	4 780
	4	3 130	1 570	–	–	1 980	414	3 180	1 600	4 370	2 800	5 580	3 990
	5	3 910	1 960	–	–	–	–	2 780	815	3 970	2 010	5 160	3 200
	6	4 690	2 360	–	–	–	–	–	–	3 570	1 220	4 760	2 410
11000	2	3 400	1 720	3 460	1 780	6 060	4 360	8 660	6 980	11 300	9 560	13 900	12 200
	3	5 100	2 570	2 600	49	5 200	2 650	7 790	5 240	10 400	7 840	13 000	10 400
	4	6 790	3 430	–	–	4 330	932	6 930	3 530	9 520	6 130	12 100	8 730
	5	8 490	4 290	–	–	–	–	6 060	1 810	8 660	4 410	11 300	7 010
	6	10 200	5 150	–	–	–	–	–	–	7 790	2 700	10 400	5 300

RPQB-Series (Pneumatic)

Model Number		Spring Torque Output		Air Torque Output at Operating Pressure—PSIG									
				40		60		80		100		120	
RPQB	Spring Set	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
11000	1 0	3 400	1 720	5 500	5 500	8 250	8 250	11 000	11 000	–	–	–	–
	1 5	5 100	2 570	5 500	5 226	8 250	8 250	11 000	11 000	–	–	–	–
	2 0	6 790	3 430	5 500	3 485	8 250	8 250	11 000	11 000	12 375	12 375	–	–
	2 5	8 490	4 290	5 500	1 744	8 250	6 999	11 000	11 000	12 375	12 375	13 750	13 750
	3 0	10 200	5 150	–	–	8 250	5 228	11 000	10 453	12 375	12 375	13 750	13 750

Performance Data

Operating Pressure Range: 40 to 120 PSIG.
*** Maximum Allowable Working Pressure: 150 PSIG.
Maximum Operating Pressure: 120 PSIG.
Operating Media: Dry or lubricated non-corrosive gas.

Operating Temperature:
Standard: −40°F to +200°F
Optional: 0°F to +350°F

Double Acting Actuators

Actuator Model	Volume Cu. In.**		Max. Oper. Pressure (MOP)	Max. Allow. Wkg. Pressure (MAWP)	Weight (Lbs.)	Oper. Time* (Seconds)
	CW	CCW				
RPB Series						
RPB250	120	133	120	150	30	02
RPB450	205	242	120	150	42	04
RPB1000	454	558	120	150	77	09
RPB2250	956	1186	120	150	155	18
RPB5000	2288	2056	120	150	410	18
RPB11000	4643	4770	120	150	820	38

*For one 90° operation with BattiSolenoid—no load (NEMA 4)
**Displacement plus cavity

Spring Return Actuators

Actuator Model	Volume Cu. In.**	Max. Oper. Pressure (MOP)	Max. Allow. Wkg. Pressure (MAWP)	Weight (lbs.)	Oper. Time Seconds*	
					Spring	Gas
RPB-Series						
RPB250-SR	133	120	150	34	06	04
RPB450-SR	242	120	150	55	11	06
RPB1000-SR	558	120	150	107	24	14
RPB2250-SR	1186	120	150	20	29	55
RPB5000-SR	2056	120	150	66	10	13
RPB11000-SR	4770	120	150	127	21	30

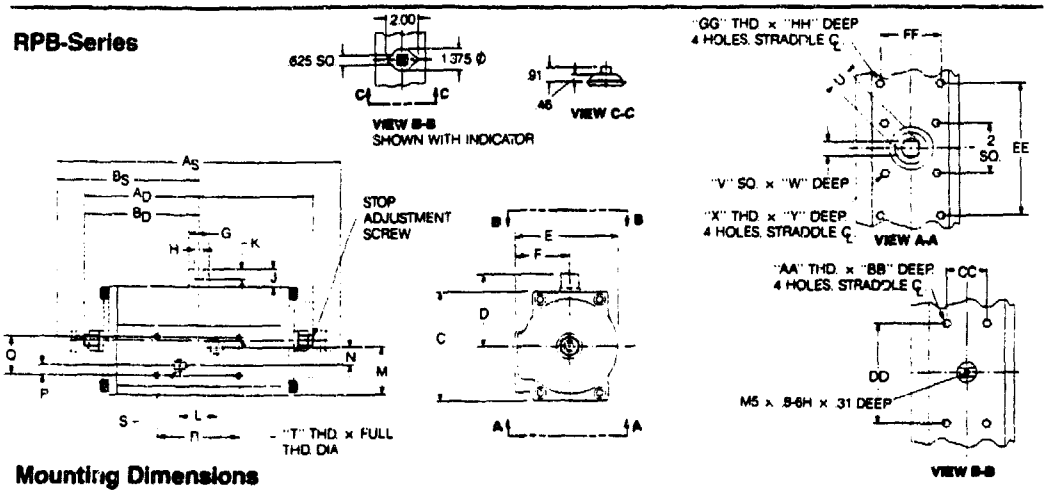
RPQB-Series

Actuator Model	Displacement In³**	Max. Oper. Pressure (MOP) Max. Allow. Wkg. Pressure (MAWP)					Weight Lbs.	Oper. Time Seconds*	
		SR 1.0	SR 1.5	SR 2.0	SR 2.5	SR 3.0		Spring	Gas
RPQB11000-SR	735	90	95	105	100	120	158	2.5	7.2

*For one 90° operation with BattiSolenoid—no load
**Displacement plus cavity
***Maximum pressure allowed on the actuator under operating conditions at the stop position

Dimensions

RPB-Series



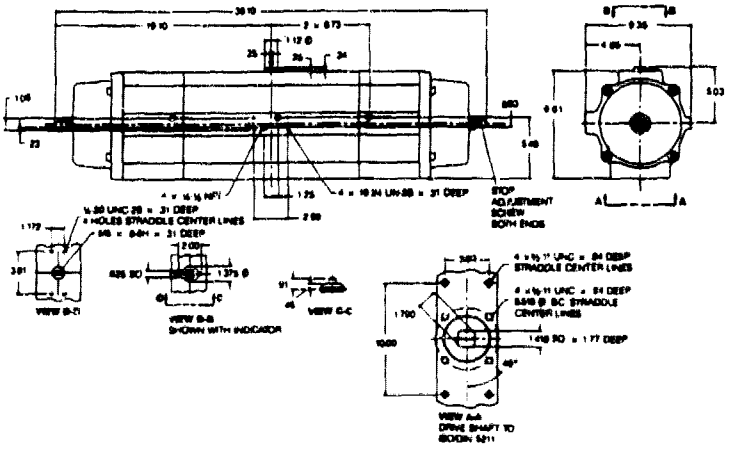
Mounting Dimensions

Model		R	S	T Thd.	U min.	V min.	W	X Thd.	Y	Z	AA Thd.	BB	CC	DD	EE	FF	GG	HH
250	in.	2.992	⅛ NPT	10-24 UNC	.56	.433	1.08	¼-20 UNC	.35	1.392	¼-20 UNC	.31	1.172	3.81	3.25	1.17	¼-20 UNC	.35
450	in.	2.992	⅛ NPT	10-24 UNC	.72	.551	1.08	¼-20 UNC	.35	1.392	¼-20 UNC	.31	1.172	3.81	3.25	1.17	¼-20 UNC	.35
1000	in.	2.992	⅛ NPT	10-24 UNC	.99	.748	1.09	5/16-18 UNC	.47	1.949	¼-20 UNC	.31	1.172	3.81	4.31	1.75	5/16-18 UNC	.38
2250	in.	2.992	⅛ NPT	10-24 UNC	1.16	.867	1.57	⅜-16 UNC	.59	2.840	¼-20 UNC	.31	1.172	3.81	4.31	1.75	⅜-16 UNC	.38
5000	in.	2.992	¼ NPT	10-24 UNC	1.32	1.063	1.36	½-13 UNC	.75	3.480	¼-20 UNC	.31	1.172	3.81	10.00	3.48	½-13 UNC	.75
11000	in.	2.992	¼ NPT	10-24 UNC	1.79	1.418	1.77	½-11 UNC	.94	3.866	¼-20 UNC	.31	1.172	3.81	10.00	3.89	½-11 UNC	.94

General Dimensions

Model		A_D	A_S	B_D	B_S	C	D	E	F	G	H	J	K	L	M	N	P	Q
250	in.	6.26	7.25	3.13	3.62	3.03	1.85	2.83	1.50	.55	.25	.34	.25	.98	1.33	.50	.281	1.062
450	in.	6.76	7.75	3.38	3.87	3.78	2.22	3.50	1.81	.55	.25	.34	.25	.98	1.39	.50	.281	1.062
1000	in.	8.69	9.75	4.34	4.87	4.72	2.71	4.43	2.38	.93	.25	.34	.25	.98	1.52	.50	.281	1.062
2250	in.	11.50	13.75	5.75	6.87	5.51	3.09	5.31	2.80	1.12	.25	.34	.25	.98	1.75	.50	.281	1.062
5000	in.	14.50	21.12	7.25	10.56	7.72	4.16	7.95	4.13	1.12	.25	.34	.25	1.25	4.48	.86	.234	1.062
11000	in.	19.00	27.25	9.50	13.63	9.61	5.03	9.35	4.88	1.12	.25	.34	.25	1.25	4.63	.86	.234	1.062

RPQB



BettiSolenoid

BettiSolenoids are custom designed for use with the RPB-Series pneumatic actuator product line offering a direct mount feature which eliminates interconnecting tubing and fittings.

General Description

1. 4-Way, 5 port, 2 position, single coil with manual override.
2. 3-Way, 2 position, normally closed, single coil with manual override.

Operation:

The valve operates when the coil is electrically energized and returns when the coil is de-energized.

Media: dry or lubricated non-corrosive gas.

Pressure:

Minimum operating differential: 35psi (2.4 bar).
Maximum operating differential: 150psi (10.3 bar).

Orientation:

Valve may be mounted in any attitude/position.

Coil Enclosure:

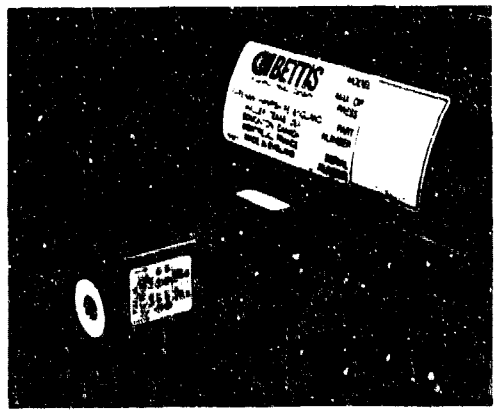
1. NEMA 4, Watertight and dust tight—indoor and outdoor. Intended for use indoors or outdoors to protect against splashing water, seepage of water, falling or hose directed water and severe external condensation. All coils are UL and CSA listed.
2. NEMA 4-7-9, combination watertight and explosion proof—indoor and outdoor. Offers the same protection as NEMA 4 listed above plus hazardous location ratings 7C, 7D, 9E, 9F and 9G (Class I & II, Groups C, D, E, F and G) Division I and II. Enclosure is UL and CSA listed.

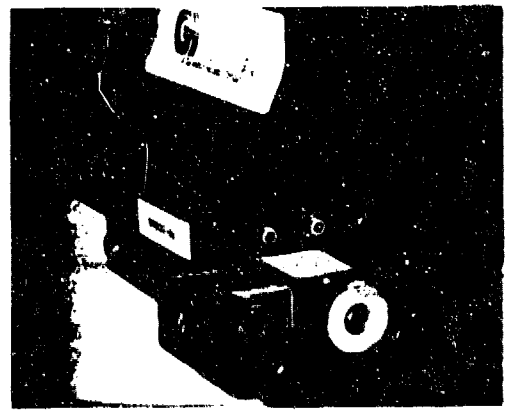
Coil Connection—NEMA 4:

1. ½ NPT Terminal type plug-in, standard.
2. Strain Relief, no cord, terminal type plug-in.
3. Strain Relief with 6 ft. (1.8m) cord, plug-in.
4. Strain Relief with 120VAC-60Hz light, no cord.
5. Strain Relief with 24VDC light, no cord, terminal type, plug-in.

Coil Connection—NEMA 4-7-9:

½ NPT., potted, 24" leads





Temperature:
Media: – 40F to + 200F.
Ambient: NEMA 4, – 40F to + 180F.
NEMA 4-7-9, – 40F to + 125F.

Coil Rating:
1. **NEMA 4:** Continuous duty molded Class H insulation.
2. **NEMA 4-7-9:** Continuous duty molded Class B insulation.

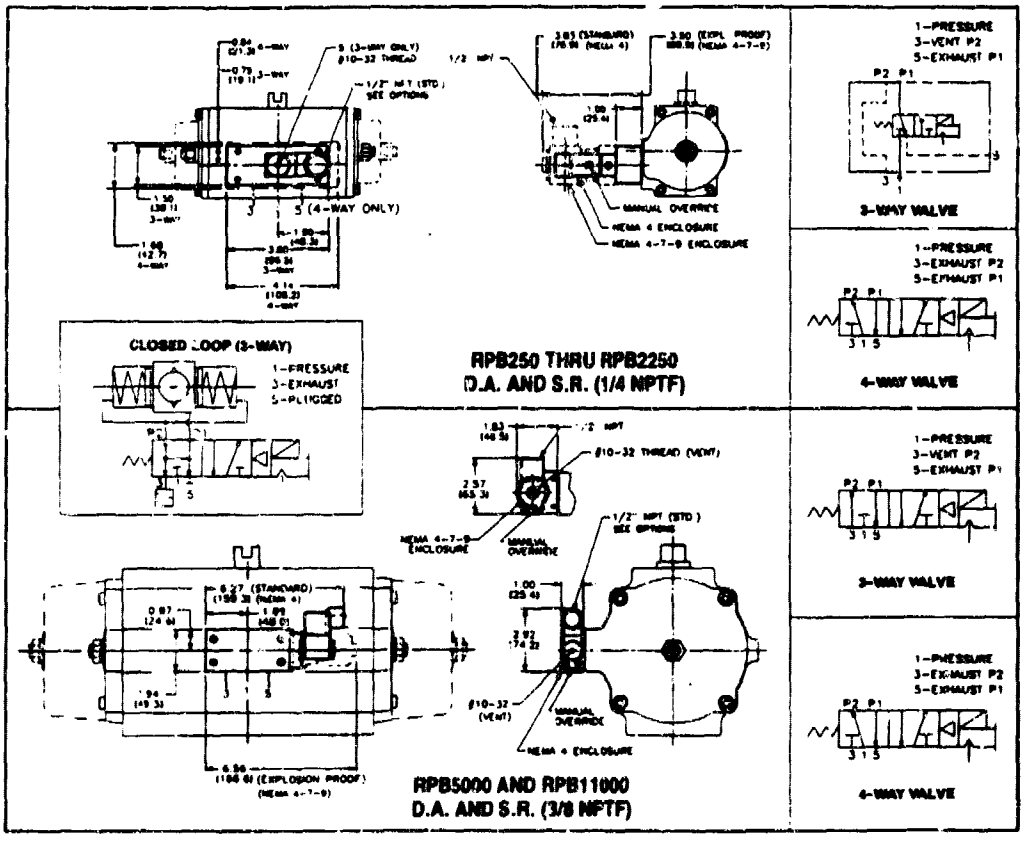
Coil Voltage:
1. 120VAC-60Hz/110VAC-50 Hz.
2. 240VAC-60Hz/220VAC-50Hz/120VDC.
3. 48VAC-60Hz/44VAC-50Hz/24VDC.
4. 24VAC-60Hz/22VAC-50Hz/12VDC.

Coil Voltage Variation: +/– 10% of Nominal.

Power Consumption: 6 Watts

Materials:
Valve Body = Aluminum, anodized.
Seals/O-Rings = Nitrile.
Fasteners = Stainless Steel assembly and attachment.

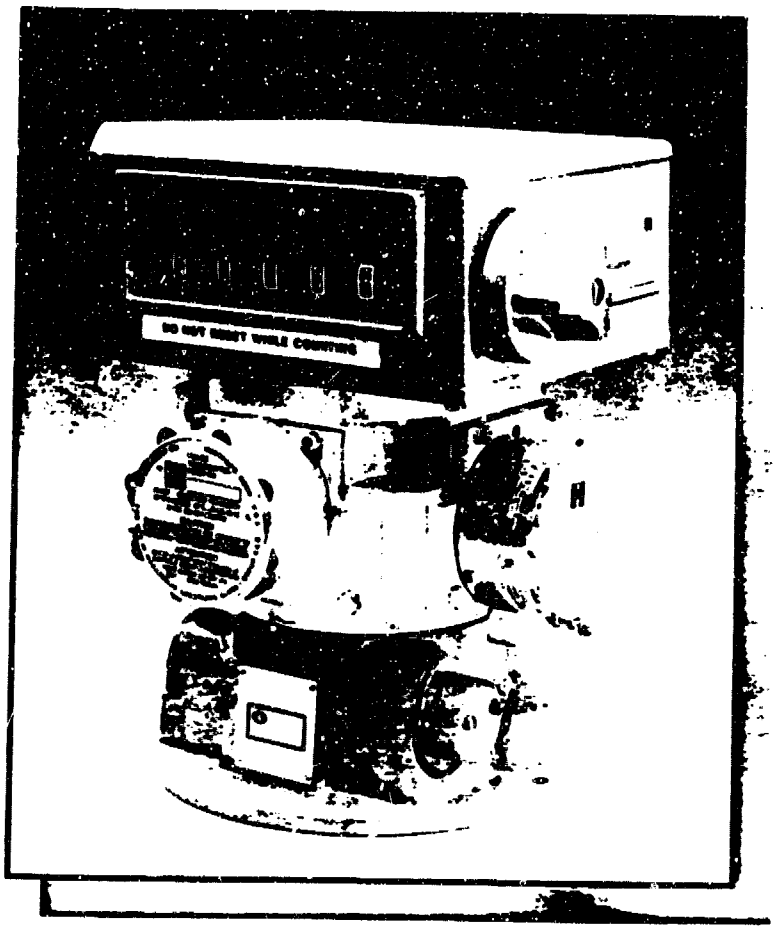
Dimensions



MULTIPLE HEAD TRANSMITTER

GATE CITY®

Multiple Head Transmitter



Application Manual
Spare Parts Ordering Guide

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MULTIPLE HEAD TRANSMITTER

The Multiple Head Transmitter is a compact and durable transmitter designed and developed by Gate City to provide from one to four outputs in a single housing with future modifications in mind. Where space limitations make stacking of several transmitters difficult, the Multiple Head Transmitter becomes the ideal alternative using only 4-5/8" of height in the meter stack.

The Multiple Head Transmitter can be used with any metering system that uses Veeder-Root accessories with a variety of adaptors and couplings to fit your meters needs. For proper transmitter application, our engineering staff will need to know what type of meter, the model number, and the volume per output shaft revolution. Our custom gear plate designs allow any volume of measurement to be used.

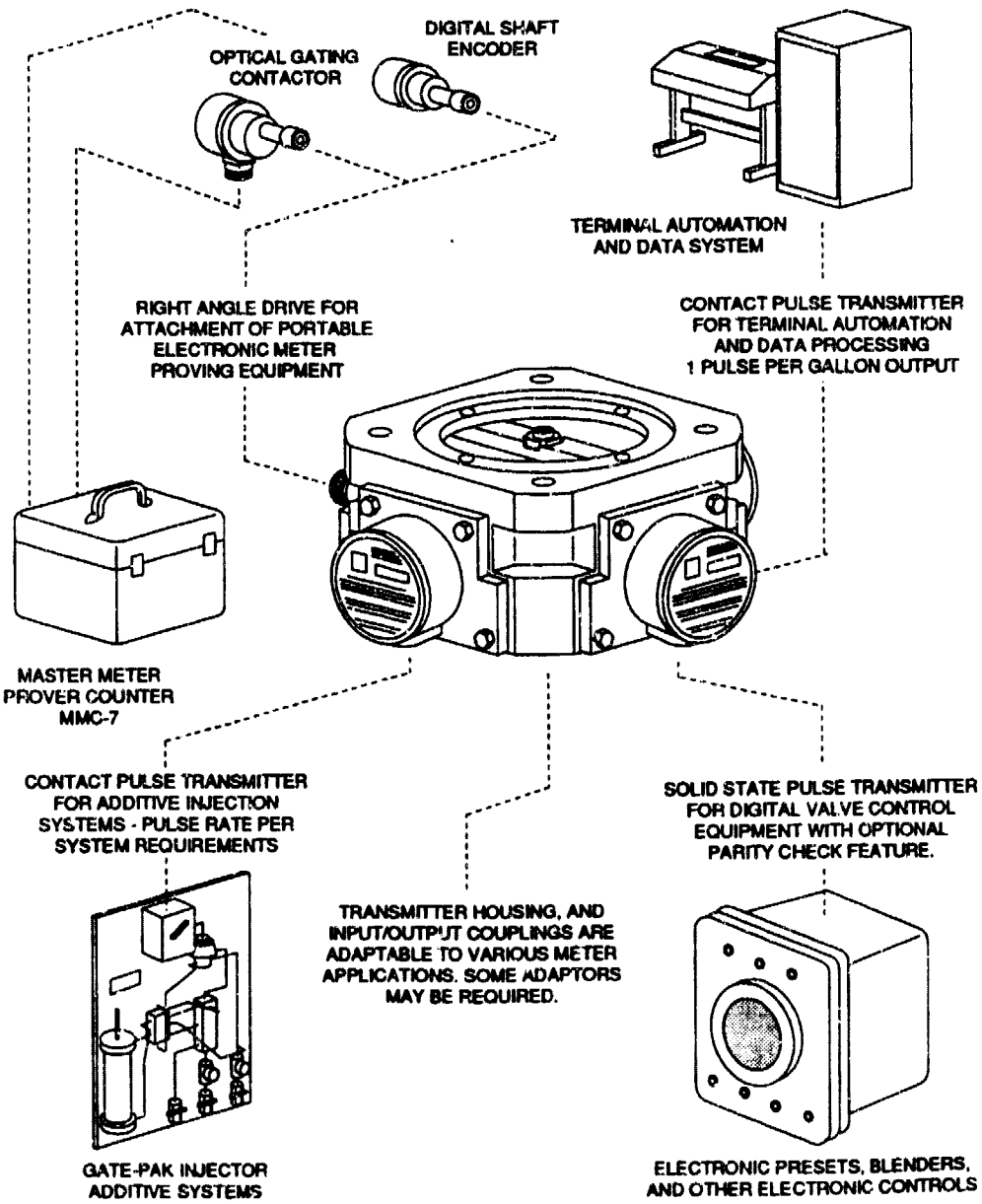
The Multiple Head Transmitter is currently available with two types of electrical outputs, both of which are enclosed in explosion-proof housings which, depending on the electrical code requirements, the approval authority can be U.L., C.S.A., BASEEFA of Ex. Most European countries will soon standardize on CENELAC which will combine BASEEFA & Ex. When a low resolution is required a Single Pole Single Throw (SPST) pulser is used, this would include such applications as 1 pulse per gallon, 1 pulse per dekaliter, or similar output. This type of pulser is normally used to signal a data system or similar device. A similar transmitter modified with a contact protection network would be used with inductive devices such as a Gate-Pak™ additive injector. For applications that require a high-resolution pulse output a Veeder-Root solid state pulser is used to supply outputs such as 100 pulses per gallon, 10 pulses per liter, etc. This type of pulser is normally used in applications such as product blending or electronic presets where a high degree of accuracy is required.

The Multiple Head Transmitter is also available with a Right Angle Drive output that can be used to drive various mechanical and electrical devices normally associated with electronic meter proving or rate of flow indicators. The Right Angle Drive can be set up to provide one output revolution per 5 gallons, 10 gallons, 1 barrel, 1 dekaliter, etc.

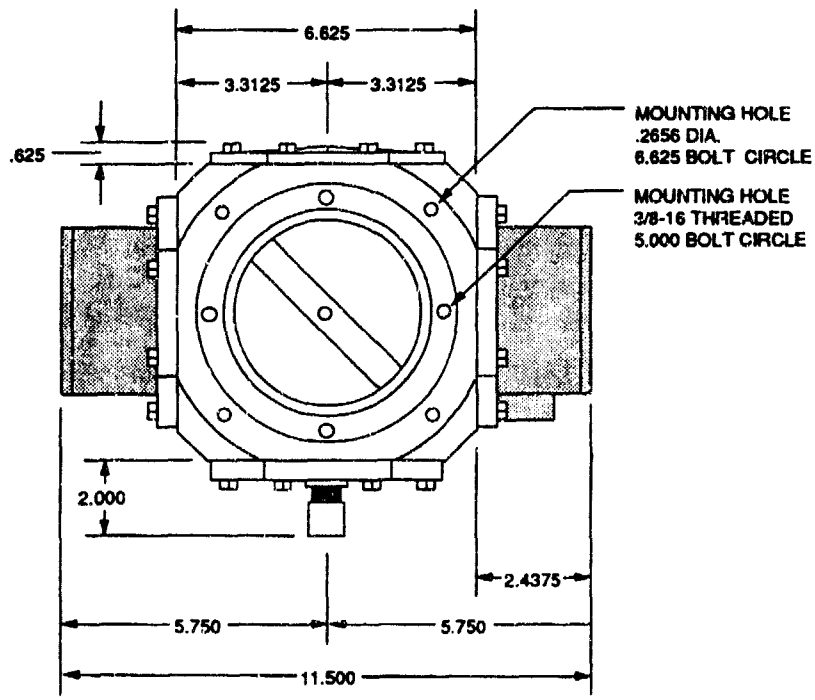
When the Multiple Head Transmitter is used and only one pulser is required at the present time, but future requirements are known, Gate City can provide your Multiple Head Transmitter with the appropriate gearing so that the correct pulser may be added in the future. The future pulser can be added merely by removing a blind plate cover, and bolting the new pulser into position.

For further information contact the Gate City distributor in your area, or contact Gate City direct and let us solve your liquid measurement problems.

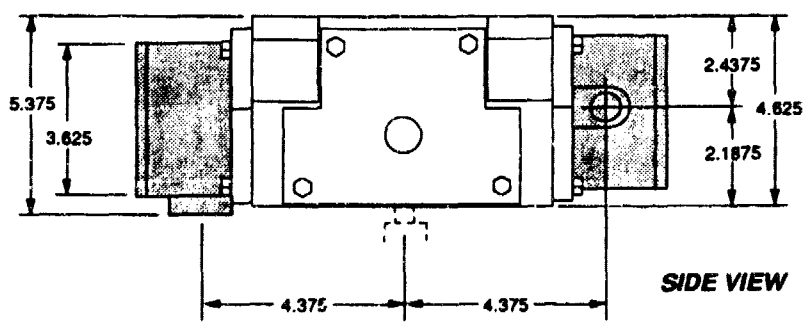
MULTIPLE HEAD TRANSMITTER APPLICATIONS



DIMENSIONS



TOP VIEW

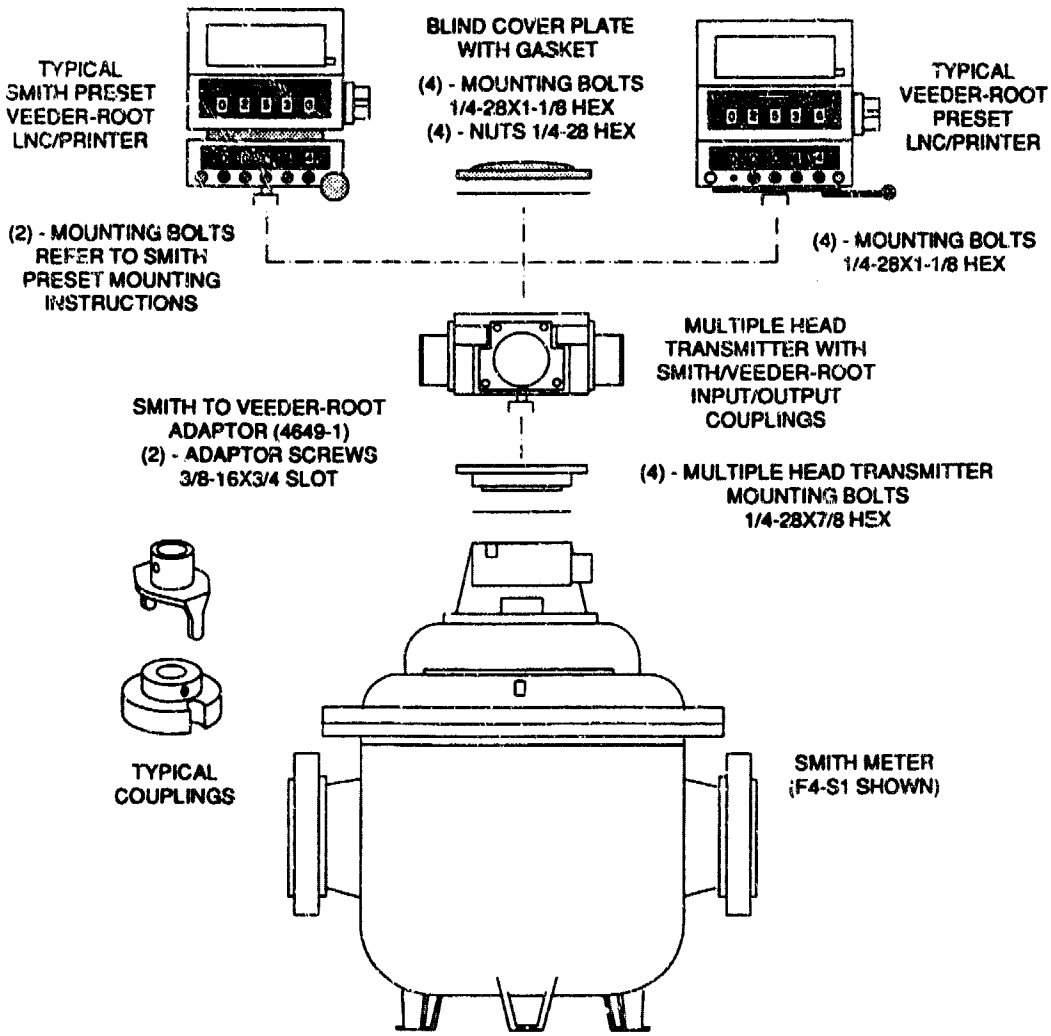


SIDE VIEW

-3-

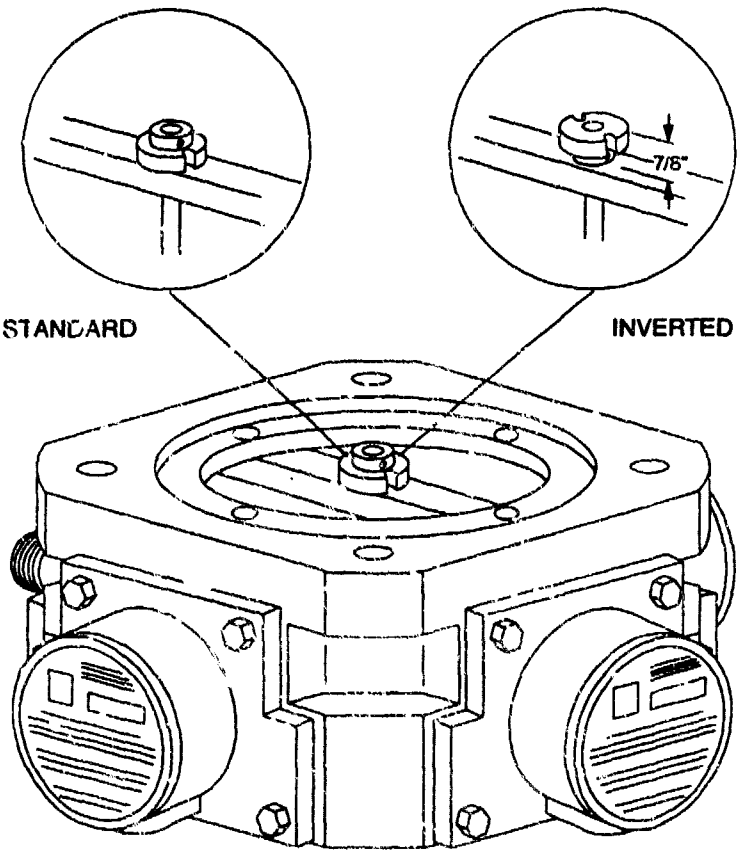
APPLICATION

SMITH METER



APPLICATION

SMITH METER



OUTPUT COUPLING APPLICATION

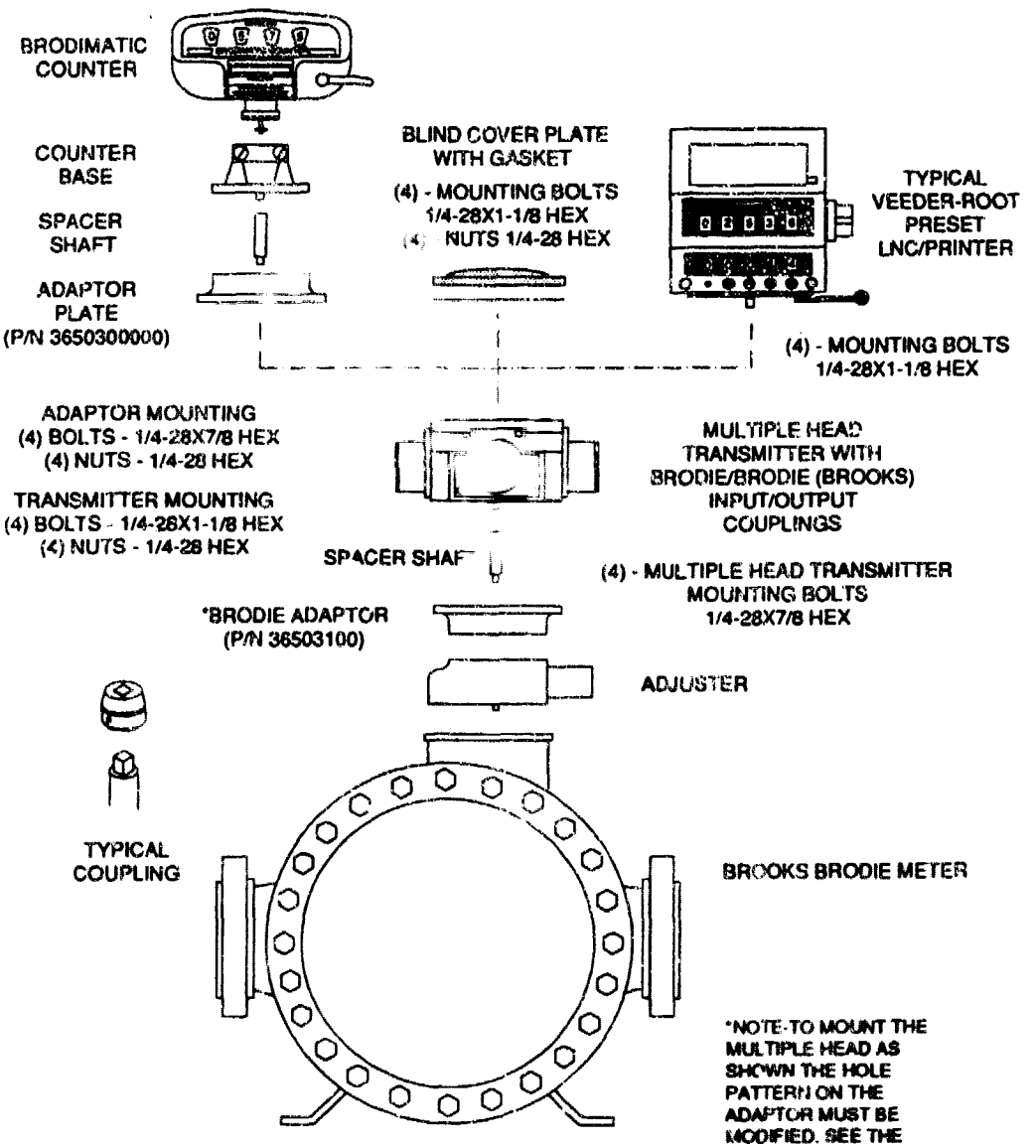
INVERTED: FOR SMITH 342 A&B SERIES PRESET AND OTHER SMITH EQUIPMENT. SEE INVERTED DETAIL. DIMENSION MUST BE AS SHOWN.

PROCEEDURE - LOOSEN SET SCREW AND INVERT COUPLING, ADJUST TO PROPER HEIGHT AND TIGHTEN SET SCREW.

STANDARD: FOR VEEDER-ROOT 340C (7889) SERIES PRESET AND COUNTER PRINTERS. SEE STANDARD DETAIL.

APPLICATION

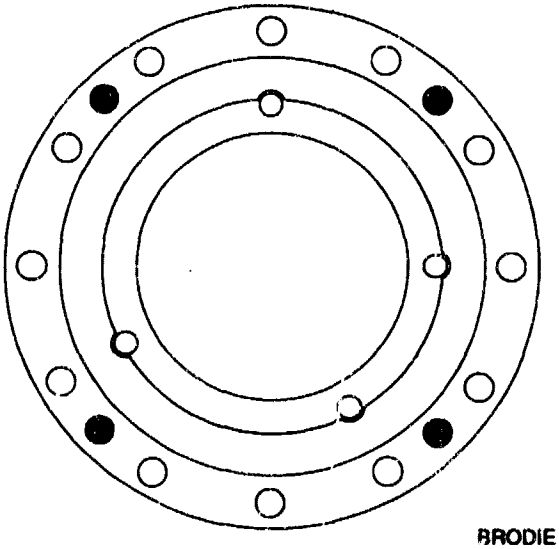
BROOKS BRODIE METER



APPLICATION

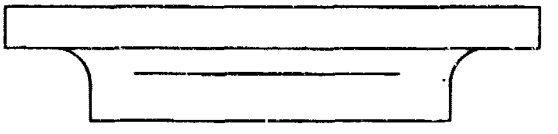
BROOKS TO VEEDER-ROOT ADAPTOR

HOLE PATTERN MODIFICATION:
LOCATE THE 4 DRILL GUIDES BETWEEN EXISTING HOLES AND DRILL NEW HOLES 3/16" DIAMETER. USE ANY 4 HOLE PATTERN FOR REQUIRED TRANSMITTER MOUNTING.



TOP VIEW

BRODIE TO VEEDER-ROOT ADAPTOR
(P/N 36503100)

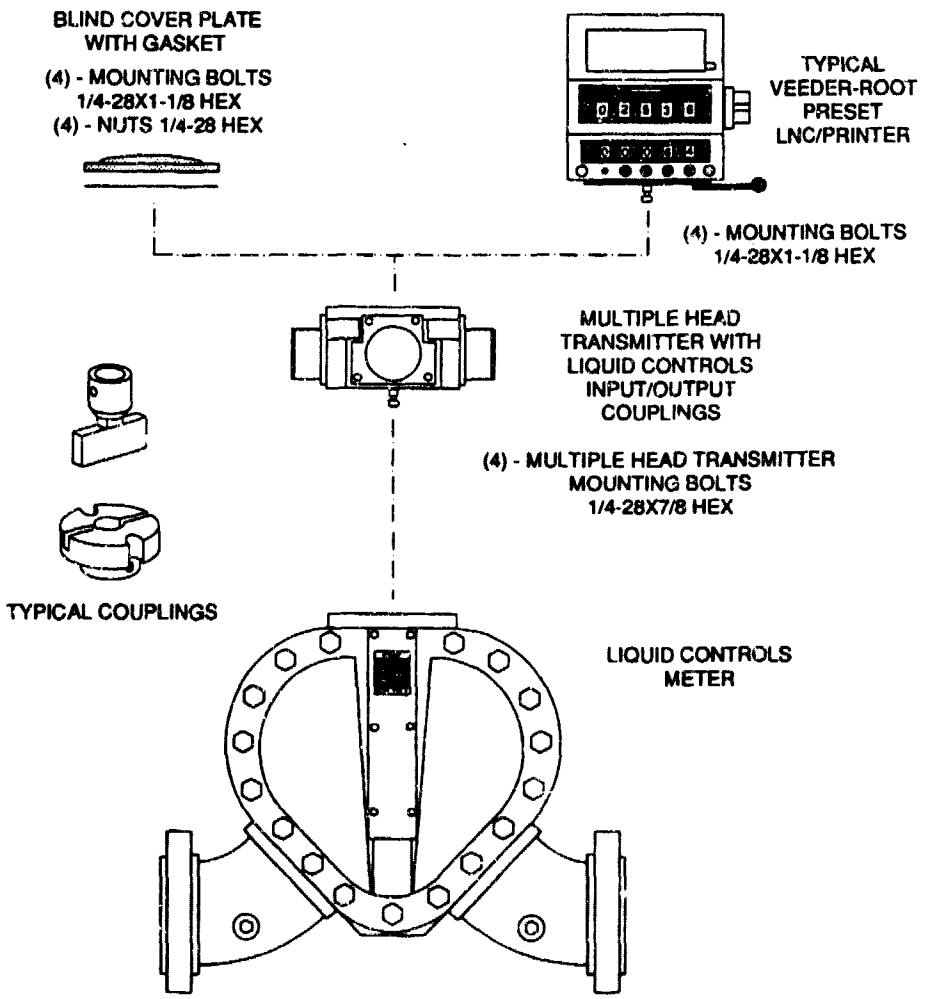


SIDE VIEW

-7-

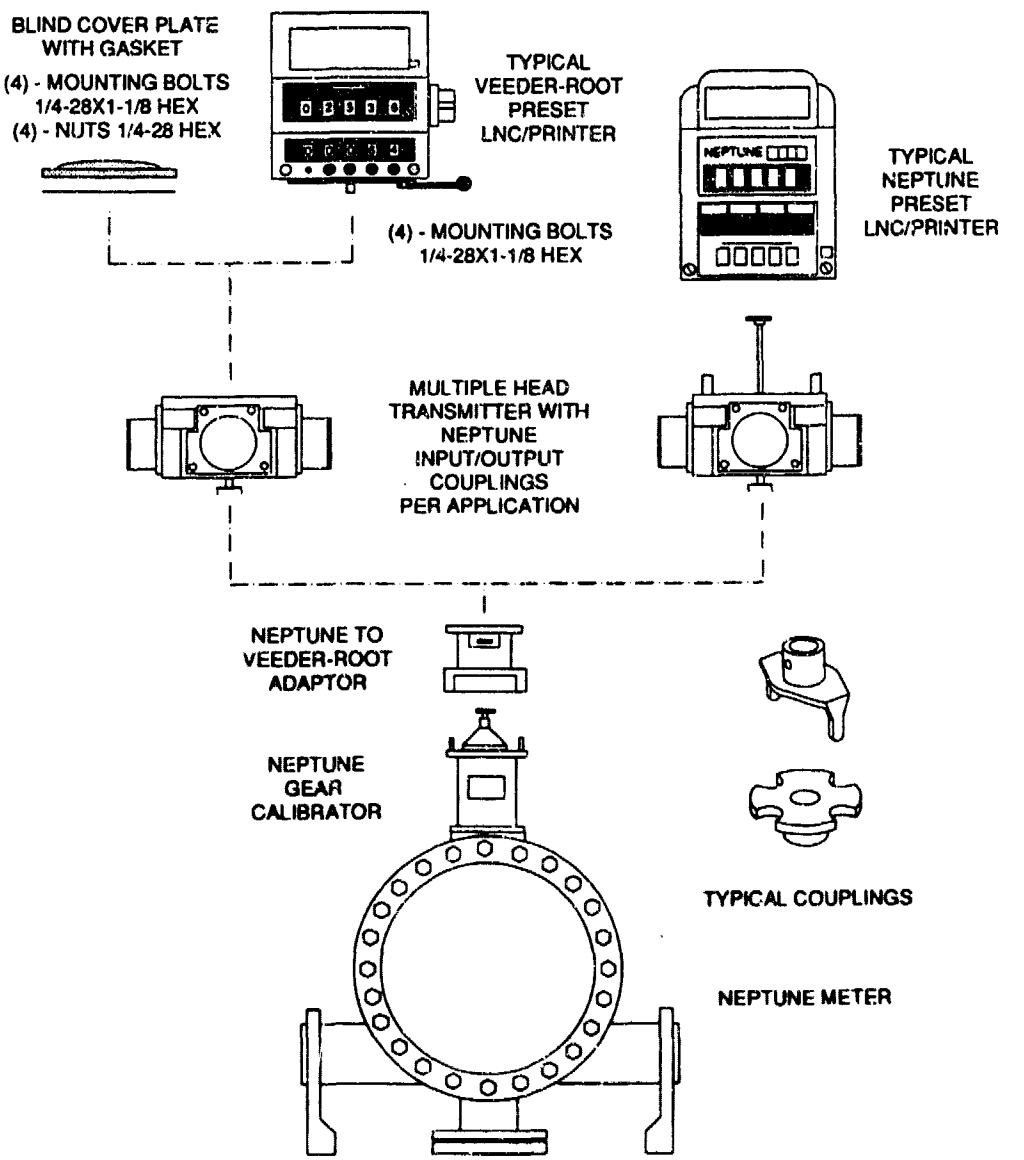
APPLICATION

LIQUID CONTROLS METER



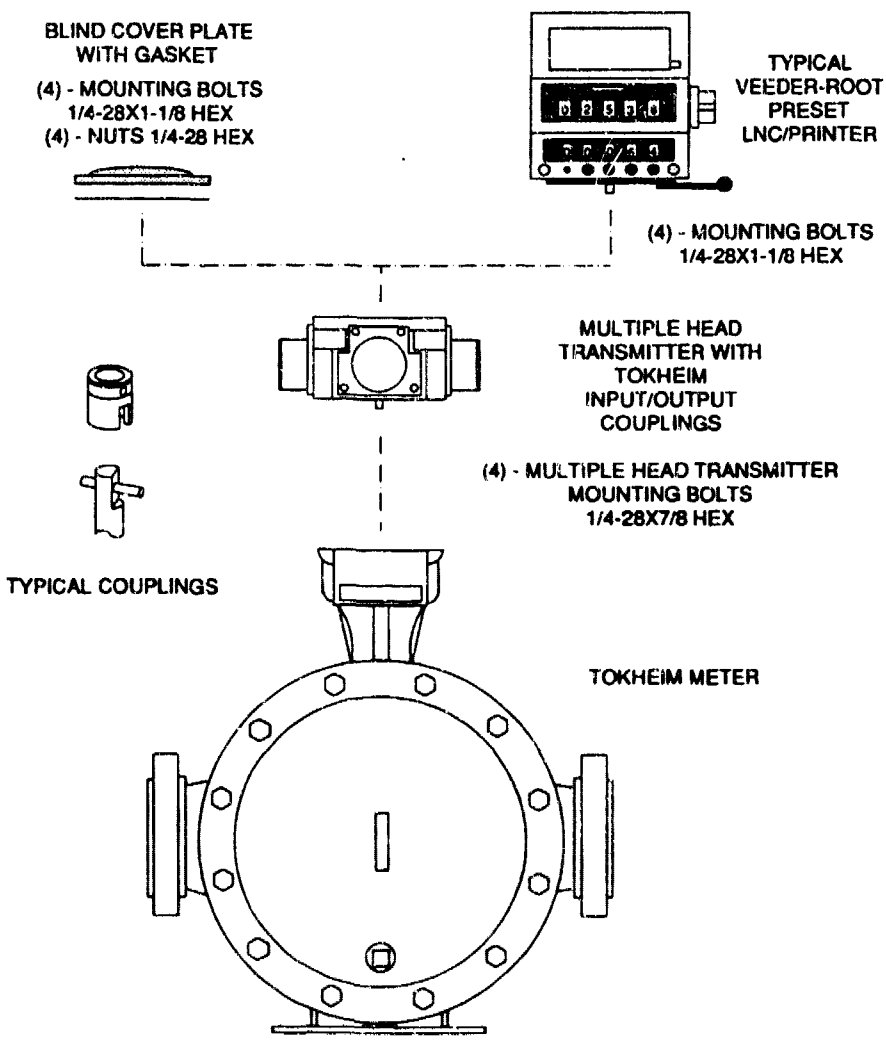
APPLICATION

NEPTUNE METER

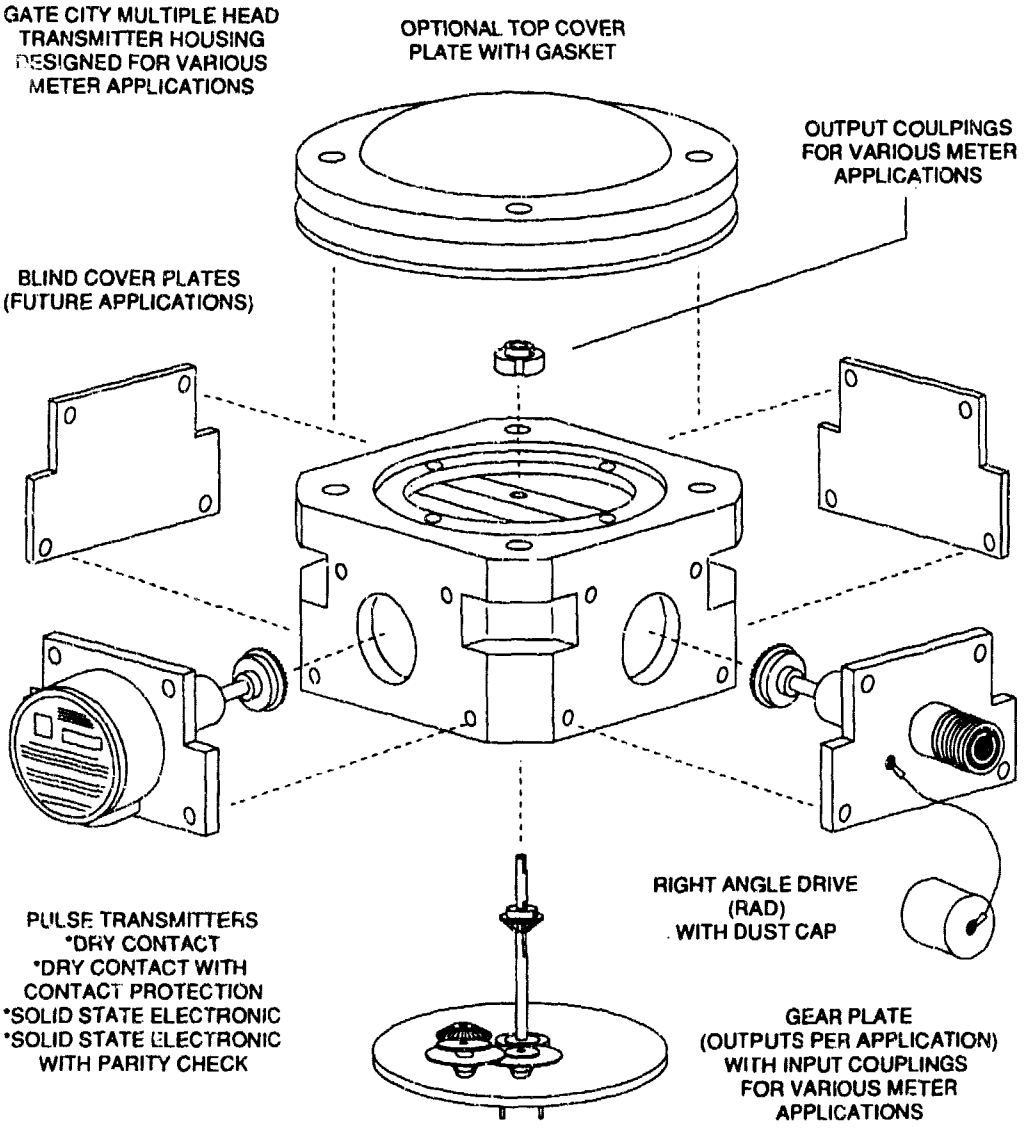


APPLICATION

TOKHEIM METER



ASSEMBLY


GATE CITY MULTIPLE HEAD TRANSMITTER HOUSING DESIGNED FOR VARIOUS METER APPLICATIONS
OPTIONAL TOP COVER PLATE WITH GASKET
OUTPUT COULPINGS FOR VARIOUS METER APPLICATIONS
BLIND COVER PLATES (FUTURE APPLICATIONS)
RIGHT ANGLE DRIVE (RAD) WITH DUST CAP
PULSE TRANSMITTERS *DRY CONTACT *DRY CONTACT WITH CONTACT PROTECTION *SOLID STATE ELECTRONIC *SOLID STATE ELECTRONIC WITH PARITY CHECK
GEAR PLATE (OUTPUTS PER APPLICATION) WITH INPUT COUPLINGS FOR VARIOUS METER APPLICATIONS

Series 1871
Pulse Transmitters

Certified LISTED

Applications

The series 1871 pulse transmitter has been designed for use with gasoline pump computers and miscellaneous electrical counters in remote indicating and data systems. It provides fast, accurate pulsing for counters, printers, and stepping motors used with remote indicating, totalizing, and data systems. UL listed, CSA certified.

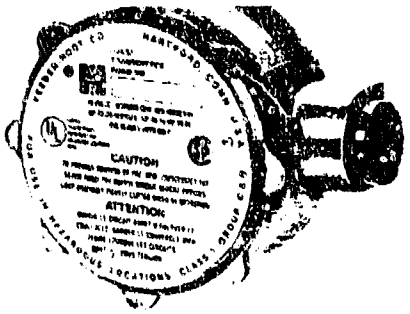
Description

The pulse transmitter chops a fixed level input voltage to form a square wave pulse with minimum contact bounce for use with transistorized circuits.

The Series 1871 pulser consists of a rugged die cast explosion proof housing with a screw type cover for easy acess to the pulsing mechanism. The transmitter utilizes a dry reed switch, magnet, and gear train, sychronized to provide 2 pulses per revolution or 10 pulses per revolution, as required.

Specifications

Contact rating	Maximum 50 VA resistive Not to exceed 250V or 3 amperes
Type switch	Single Pole Single Throw
Contact Resistance	500 milliohms
Actuating Time	1 milisecond average
Contact bounce	1 milisecond average
Speed	0-3000 pulses per minute, 600 RPM maximum
Pulse Timing	40 to 50% on, the balance off
Temperature	Compensated for -40°F to + 160°F
Housing	UL/CSA, explosion-proof Class 1, Groups C & D Cover holes provided for wire seal



Series 767181 Pulse Transmitters

LISTED

Description

These solid state pulse transmitters provide fast and accurate signaling for remote indication, totalizing, and data monitoring systems. They are UL listed for gasoline pump computers and in applications that require monitoring of output shaft rotation in hazardous locations.

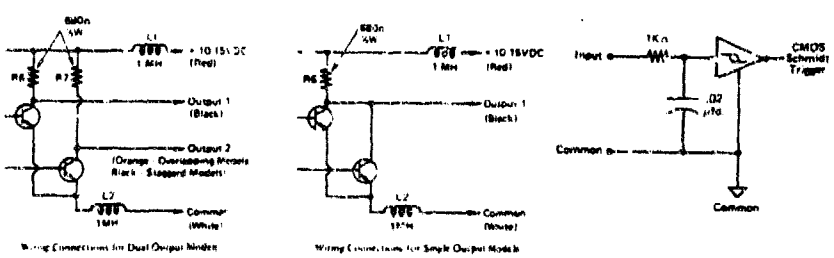
The output can be either dual channel with 50 pulses per revolution per channel or single channel with 100 pulses per revolution. The dual channel pulse trains can be staggered or overlapping. A staggered output allows errors to be detected on either channel or on both concurrently(power loss to pulser). An overlapping output permits the detection of direction of rotation and errors on either channel, but not both concurrently. The single channel devices are used when greater pulse density is desired and error detection is not required.

Specifications

Recommended Operating Conditions

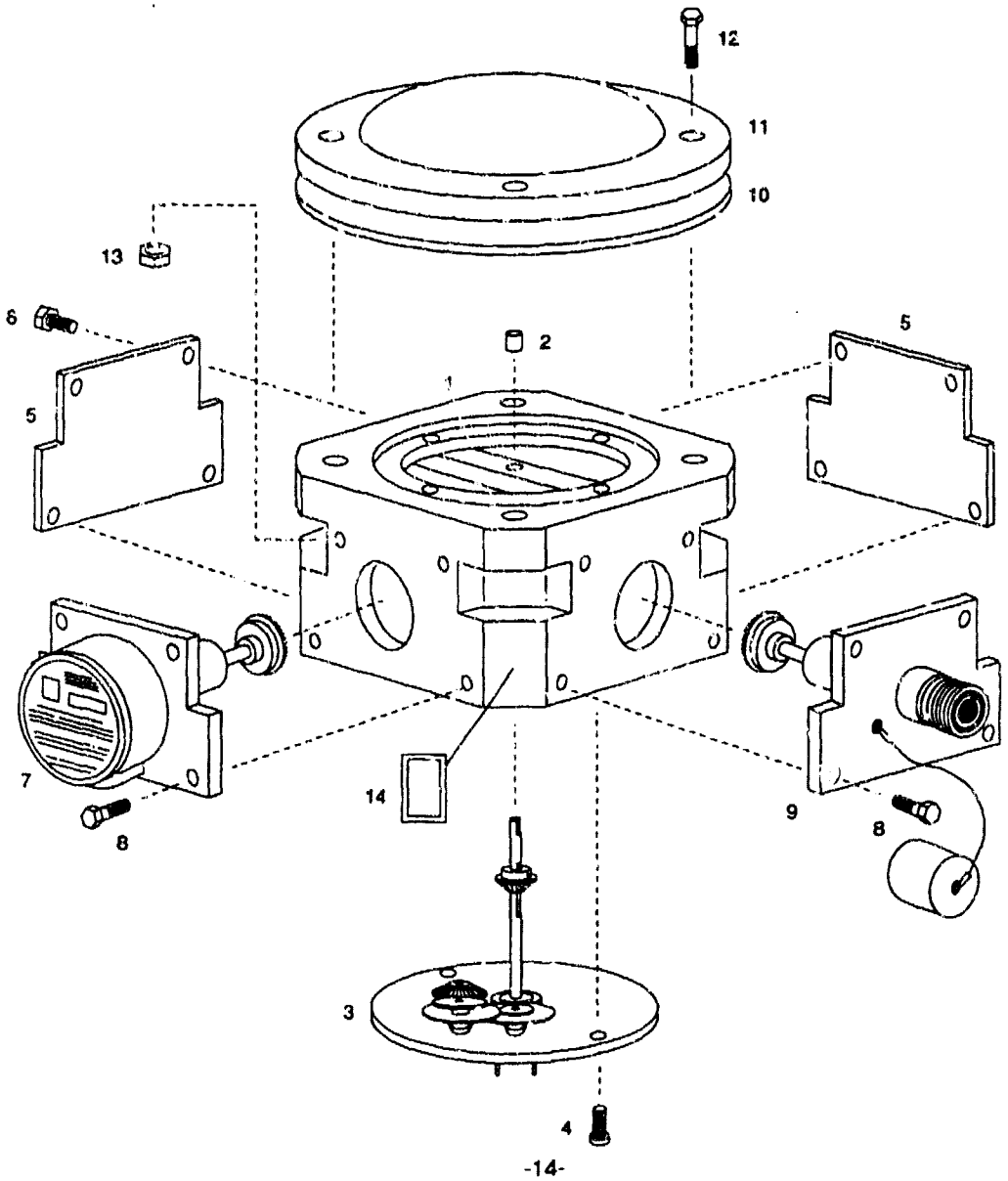
Supply voltage	10-15v DC; 75 ma max a 15v DC
Output	Dependent on load
Switching times	Rise time - 2 microseconds maximum Fall time - 4 microseconds maximum
Input shaft speed	600 RPM
Operating Environment	-40°F to 180°F (-40°C to 32°C)
Housing	Explosion-proof. For use in Hazardous locations Class 1, Group D

SCHEMATIC



PARTS

HOUSING - MAJOR COMPONENTS



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PARTS LISTING

HOUSING - MAJOR COMPONENTS

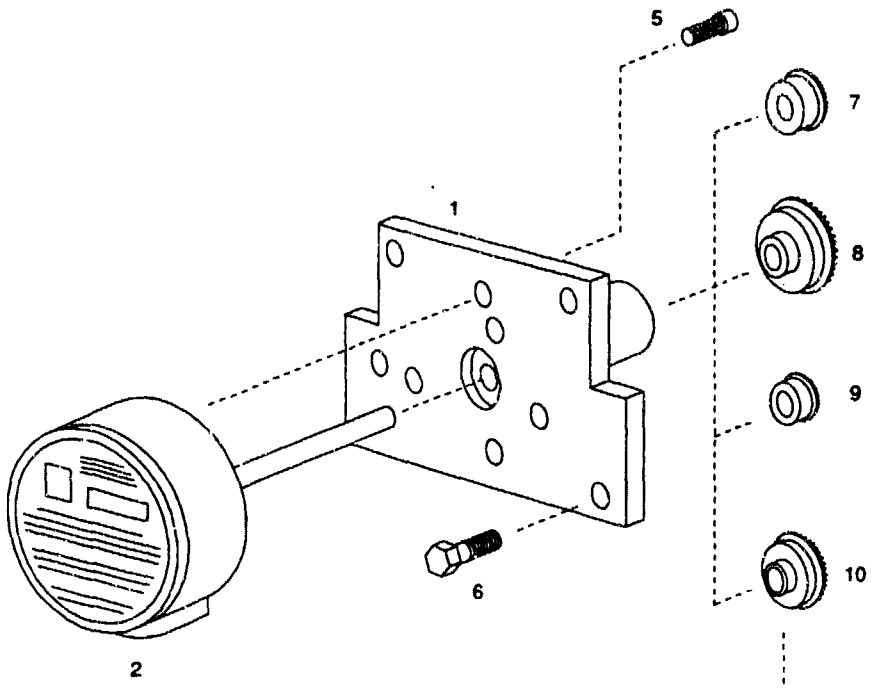
ID #	Description	Part Number
1	Base housing	02-00004
2	Bushing	02-00050
3	Gear plate (Standard 16:1)	02-00075*
4	Gear plate screws (2 req)	02-00052
5	Blind plate	02-00006
6	Blind plate bolt	02-00057
7	Add-on Pulser	
	2 pulses per revolution	02-00100**
	10 pulses per revolution	02-00200**
	100 pulses per revolution	02-00300**
8	Pulser mounting plate bolt	02-00059
9	Right angle drive adaptor	02-00400
10	Blind cover gasket	02-00080
11	Blind cover	02-00085
12	Blind cover bolt	02-00087
13	Blind cover nut	02-00088

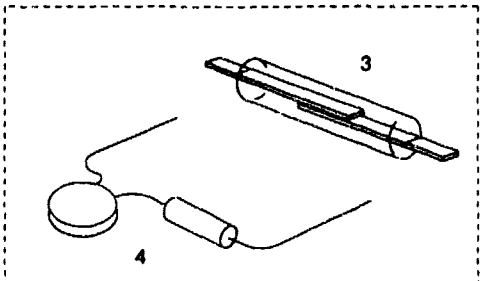
* To insure the correct replacement gear plate will require the original Multiple Head Transmitter serial number

** To insure the correct replacement or add-on pulser will require the original Multiple Head Transmitter serial number

PARTS LIST

PULSE TRANSMITTERS





DRY CONTACT PULSER PARTS

PARTS LISTING

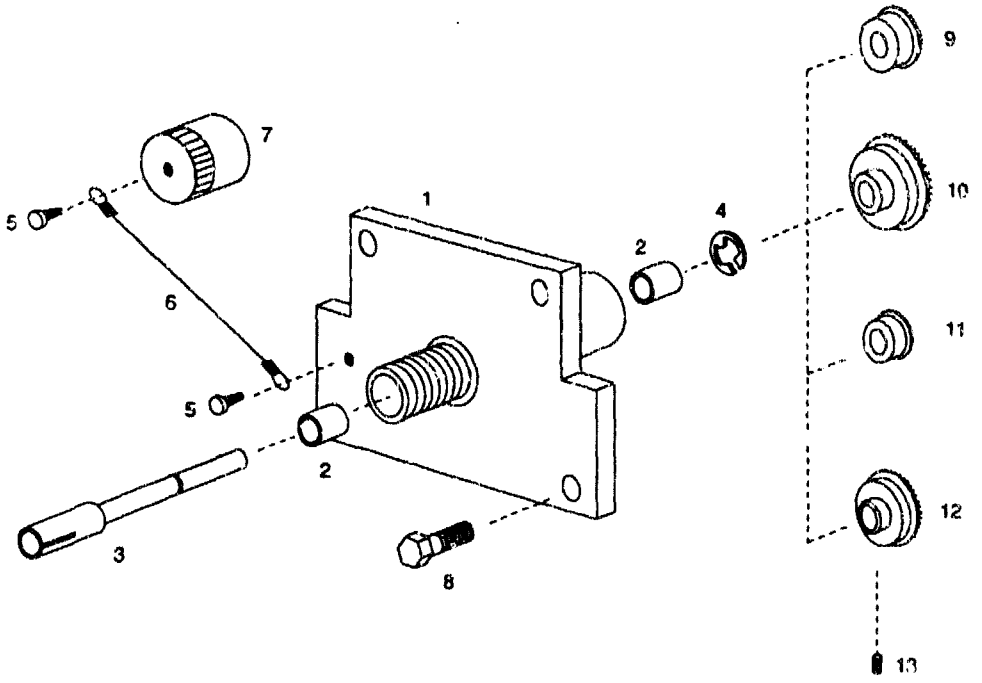
PULSE TRANSMITTERS

ID #	Description	Part Number
1	Pulser mounting plate	02-00029
2	Pulser	
	2 PPR* (187180-051)	02-00034
	10 PPR(187180-052)	02-00035
	100 PPR (767181-325)	02-00036
	100 PPR with parity check (767181-325P)	02-00037
3	Reed switch	02-00099
4	Contact protection network	02-00010
5	Pulser mounting screw	02-00105
6	Pulser mounting plate bolt	02-00059
7	24 Tooth pulser drive gear	02-00002
8	36 Tooth pulser drive gear	02-00003
9	18 Tooth pulser drive gear	02-00001
10	Veeder Root pulser drive gear	02-00110
11	Set Screw, drive gear	02-00115

* Pulses per revolution

PARTS LIST

RIGHT ANGLE DRIVE



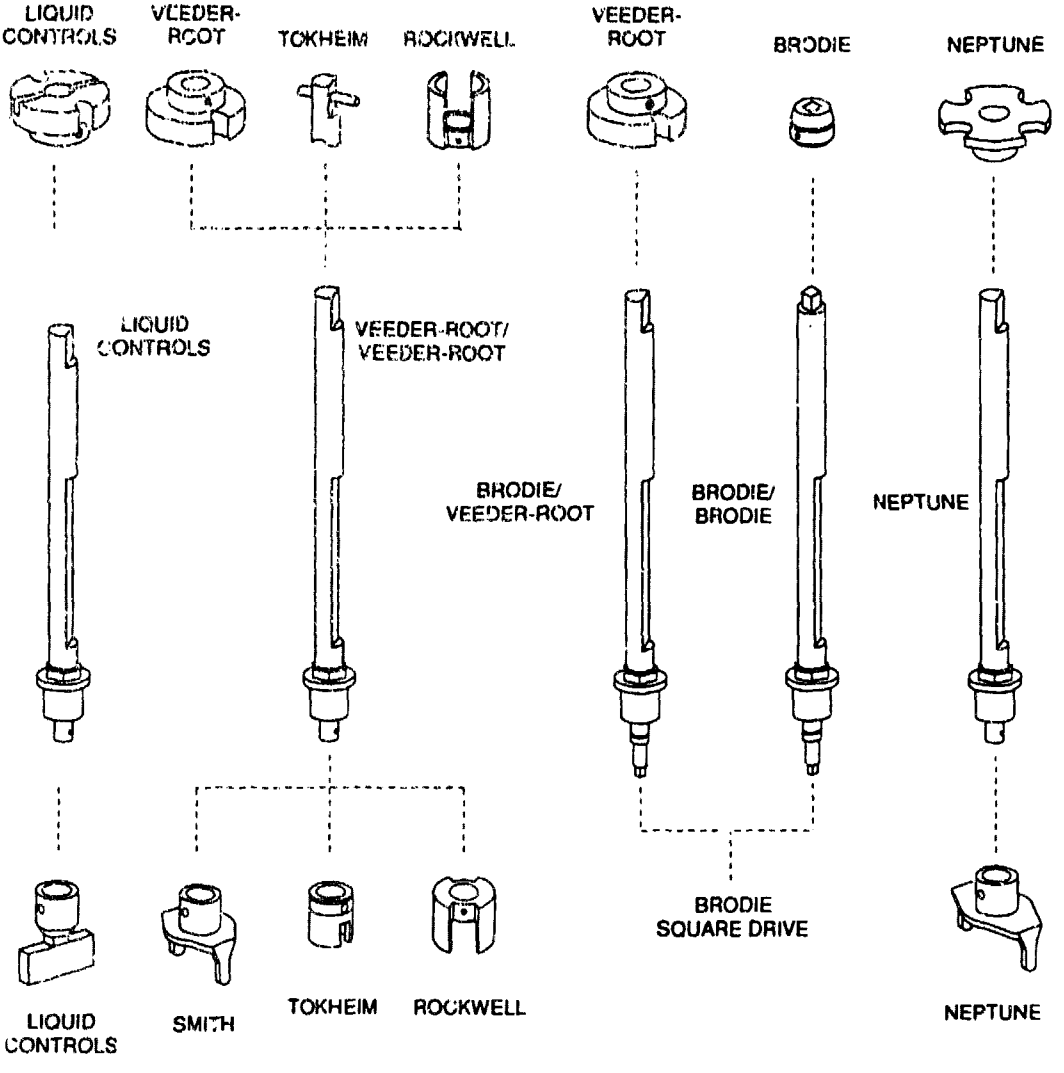
PARTS LISTING

RIGHT ANGLE DRIVE

ID #	Description	Part Number
1	Right angle drive plate	02-00022
2	Bushing	02-00050
3	Shaft	02-00024
4	Retaining ring	02-00120
5	Drive screw	02-00122
6	Cable	02-00124
7	Cap	02-00023
8	Mounting bolt	02-00059
9	24 Tooth pulser drive gear	02-00002
10	36 Tooth pulser drive gear	02-00003
11	18 Tooth pulser drive gear	02-00001
12	Veeder Root pulser drive gear	02-00110
13	Set Screw, drive gear	02-00115

PARTS LIST

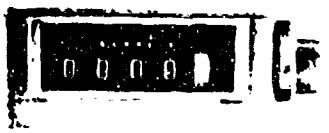
SHAFTS AND COUPLINGS



PARTS LISTING

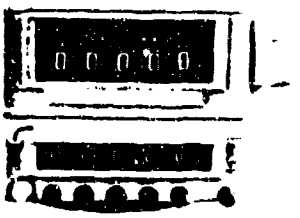
SHAFTS AND COUPLINGS

Description	Part Number
Liquid Controls Output coupling	02-00016
Liquid Controls shaft	02-00014
Liquid Controls Input coupling	02-00015
Veeder-Root (Smith) Output coupling	02-00027
Veeder-Root to Veeder-Root (Smith)shaft	02-00028
Smith Input coupling	02-00060
Tokheim Input (Pin)	02-00065
Tokheim shaft	02-00070
Tokheim Input coupling	02-00072
Rockwell Output coupling	02-00091
Rockwell Input Coupling	02-00093
*Rockwell couplings use shaft PN 02-00028	
Brodie to Veeder-Root shaft	02-00009
Brodie Output coupling	02-00008
Brodie to Brodie shaft	02-00130
Neptune Output coupling	02-00020
Neptune shaft	02-00017
Neptune Input coupling	02-00018



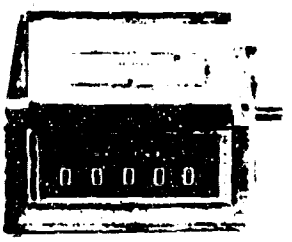
The 7887 Veeder-Root Meter Register

The Fluid Power Product's Meter fitted with the 7887 Veeder Root Register is an outstanding choice for recording and displaying delivery data in a wide variety of industries. This system totalizes and displays high speed deliveries and transactions in large easy-to-read figures, and it is ideal for increased efficiency in all kinds of liquid inventory and delivery operations.



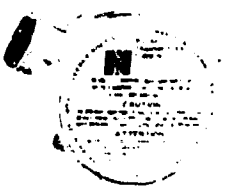
The 7891 Veeder-Root Meter Register and Preset

The Fluid Power Product's Meter fitted with the 7891 Meter Register and Preset combines inventory control and data processing information for a wide variety of industries. This system combines to control and display high speed fluid deliveries and transactions and it is ideal for increased efficiency in all kinds of liquid inventory monitoring and control installations.



The 7890 Veeder-Root Meter Register and Printer

The Fluid Power Product's Meter fitted with the 7890 Meter Register and Printer provides inventory control records, bill of lading, receipts or invoices, accounting records and data processing information in a wide variety of industries. This system produces clean, detailed printed records of high-speed fluid delivers and transactions, and it is ideal for increased efficiency in all kinds of liquid inventory monitoring and control situations.



The 7671 Solid State Pulse Transmitter and the 1871 Pulse Transmitter

These two pulse transmitters mounted to Fluid Power Product's Meter are designed to provide fast, accurate pulsing for counters, printers and stepping motors used with remote indicating, totalizing, and data systems. The 1871 transmitter provides a choice of 1 or 10 ppr. The 7671 output pulse can either be dual channel with 50 ppr or single channel with 100 ppr.

Fluid Power Products Positive Displacement Flow Meters

Accepted around the world in the Petroleum, Chemical, Agricultural, Pharmaceutical, Food, Utility and Military Markets, these meters are cost-effective high performance meters. Constant attention to new product development, production design, high standards of manufacture and final testing are the reasons Fluid Power Products meet the most demanding requirements of various types of industry.

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FAX # (504) 542 7394

MS 1002

LIQUID LEVEL SWITCHES

Liquid Level Switches for Pressure Vessels

L-1200 & L-1100 Float Operated Switches

Also L-1000 Series Float Switches for Normal Pressure Applications

Bulletin LL-7434
Revised 10-89
Catalog Section 15

DESCRIPTION

The L-1200 is a float switch for high pressure vessels, functioning to activate alarms and/or to shut-down equipment when a liquid rises high enough to set the snap-switch. All other models in the L-1000 series operate in this manner, but vary in application, material make-up, pressure rating, and size.

Designed to meet specification for Class I, Division 1, Group C & D hazardous locations, the L-1200 and L-1100 are certified by the Canadian Standards Association. These units are explosion proof constructed and all moving parts coming into contact with a fluid are corrosion resistant.

INSTALLATION

Level switches may be mounted directly onto a tank wall or indirectly by means of standoff piping and float chamber. For direct mounting of the L-1200 Murphy manufactures a weld collar that is mechanically designed to allow full float travel in switching. Also manufactured is a float chamber (1500 psi rating) for installations requiring isolation of the float from turbulent or rapidly fluctuating liquid levels. Either mounting should be installed per ASME pressure vessel code.

Examine typical float chamber and weld collar installations. Take special note in float chamber installation of the hammer lug union on the lower horizontal pipe: one or more such unions are necessary to facilitate mounting.

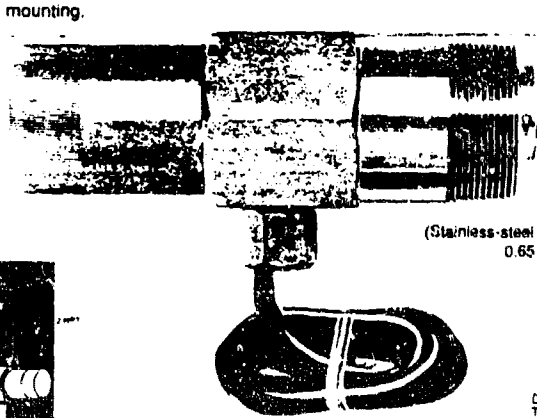
L-1200, L-1100 Works Effectively On:

- Compressor Scrubbers
- Pressure Vessels
- Heater Treaters
- Boilers
- Any Equipment Needing a Liquid Level Monitor

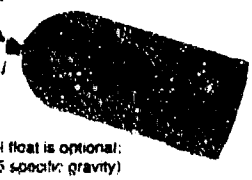
Murphy

Patent No. 3570059

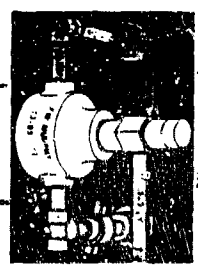
L-1200



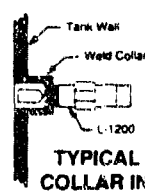
Murphy Buoyglas™ Float;
0.5 specific gravity.



(Stainless-steel float is optional;
0.65 specific gravity)



TYPICAL L-1200 FLOAT CHAMBER INSTALLATION



TYPICAL L-1200 WELD COLLAR INSTALLATION

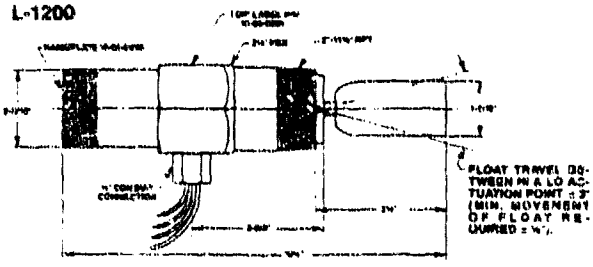
FLOAT SWITCH MODELS:

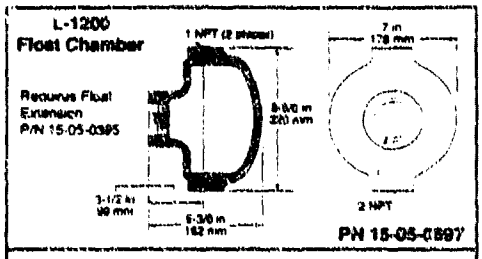
MODEL	DESCRIPTION
L-1200*	1500 psi/10.3MPa pressure rating, 2" NPT BUOYGLAS™ Float, SPDT**, fits Murphy Float Chamber or Weld Collar.
L-1200-SS*	Stainless-steel body and cover.
L-1100	1500 psi/10.3 MPa pressure rating, 1 1/2" NPT, BUOYGLAS™ Float, SPDT**.
L-1250	15 psi/103 kPa pressure rating, 2" NPT, Polypropylene Float, SPDT**.
L-1150	15 psi/103 kPa pressure rating, 1/2" NPT, Polypropylene Float, SPDT**.

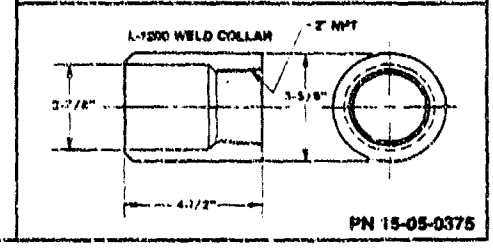
*ALSO: Model for 400°F Service with Stainless-Steel Float.
**All models can be ordered with a DPDT switch, specify by designator DPDT.

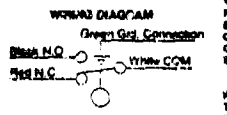
ALSO, SEE NOTES BACK PAGE

L-1200



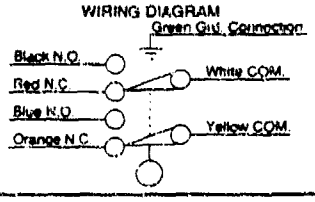




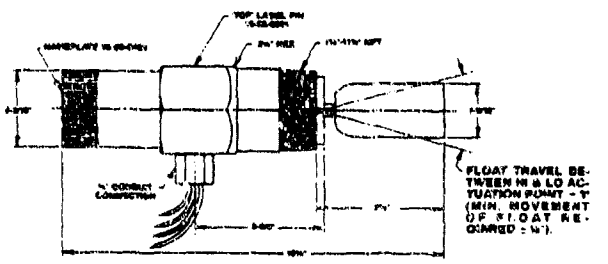


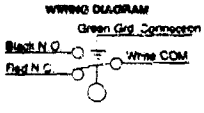
Wire: 18 AWG x 36" Long (4)
Float: BUOYGLAS™
Body and Cover: Electroless Nickel Plated
O rings: Viton
Operating Specific Gravity: 0.5
Switch Rating: 5A @ 125 - 480 VAC
1.5A 125 VDC; 1/4A 250 VDC
2A resistive 30 VDC 1A inductive 30 VDC
Pressure Rating: 1500 psi/10.3 MPa
Temperature Rating: 300°F
Shipping Weight: 7 lbs /3.2 kg

L-1200 DPDT, L-1100 DPDT ††
15-00-0136 Micro Switch Assembly
Switch Rating 10A @ 250 VAC



L-1100





Wire: 18AWG x 36" Long (4)
Float: BUOYGLAS™
Body and Cover: Electroless Nickel Plated
O rings: Viton
Operating Specific Gravity: 0.5
Switch Ratings: 5A @ 125 - 480 VAC
1.5A 125 VDC; 1/4A 250 VDC
2A resistive 30 VDC 1A inductive 30 VDC
Pressure Rating: 1500 psi/10.3 MPa
Temperature Rating: 300°F
Shipping Weight: 6 lbs /2.7 kg

REPLACEMENT PARTS

Parts	Description
L-1200	
15-05-0899	Float: BUOYGLAS™
15-00-0124	Micro Switch Assembly
15-01-0214	Counter Balance Assembly
Consisting of:	
15-01-0209	Lever Assembly
15-05-0383	Hinge Pin
15-05-0002	Washers: Nylon
15-05-0867	Spring Return
L-1100	
15-05-0899	Float: BUOYGLAS™
15-000124	Micro Switch Assembly
15-01-0213	Counter Balance Assembly
Consisting of:	
15-01-00209	Lever Assembly
15-05-0252	Hinge Pin
38-05-0002	Washers: Nylon
15-05-0567	Spring Return

NOTES

† The following items on the L-1200, L-1200 DPDT, L-1100, and the L-1100 DPDT can be replaced or recalibrated at the factory: O rings, Guide Shaft assembly, Operating Lever.

†† L-1200 DPDT, L-1100 DPDT: Replacement parts are the same as the L-1200 and the L-1100 except for Micro Switch Assembly; Part Number 15-00-0136. See wiring diagram above.

A 5/16 diameter x 1" length Float Shaft Extension can be ordered. Ask for Part Number 15-05-0395. Will be shipped loose.

A stainless steel float is available, 0.65 specific gravity. Ask for Part Number 15-05-0166 for the L-1200; 15-05-0356 for the L-1100.

*Stainless Steel Models comply with the National Association of Corrosion Engineers (NACE) Standard MR-01-75 for exposure to H_2S, in hydrocarbon bearing service, for resistance to Sulfide stress cracking.

Specifications subject to change without prior notice.

Murphy Since 1939

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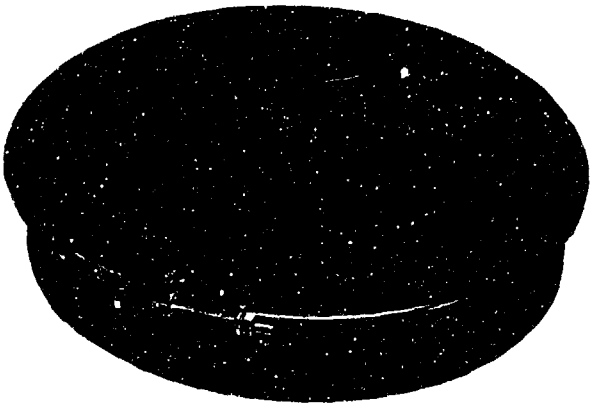
Murphpak Pty., Ltd.
1620 Hume Highway; Campbellfield, Vic 3061; Australia
tel. (61) 3-358-5555 fax (61) 3-358-5556

#01542M

INSPECTION MANHOLE

KF 16" AND KG 20" INSPECTION MANHOLES



The KF 16" and the KG 20" Inspection Manholes give excellent service when there is no need for a fill opening or venting. These units are available in steel, aluminum or stainless steel.

The covers are easy to remove for tank inspection.

Standard for both units is a black Buna N gasket, which is held in place by retainer clips welded to the cover.

KF 16" INSPECTION MANHOLE

OVERALL HEIGHT: 3⅞" (Approximately) AVERAGE SHIPPING WEIGHT: Steel — 14 pounds Aluminum — 6 pounds

MODEL		COVER MATERIAL		WELD RING 16" ID		GASKET		VENT	
TYPE	CODE	CONTACT PARTS	EXTERNAL PARTS	CODE	MATERIAL	CODE	MATERIAL	CODE	TYPE
KF	1	Steel	Steel	1	3" Steel 12 gauge	1	Black Buna N	0	No Vent
	2	Aluminum	Plated	2	Aluminum 3" x ⅛"				
	3	SS 304	Plated	3	3" 304 SS 12 gauge				
	4	SS 304	SS						

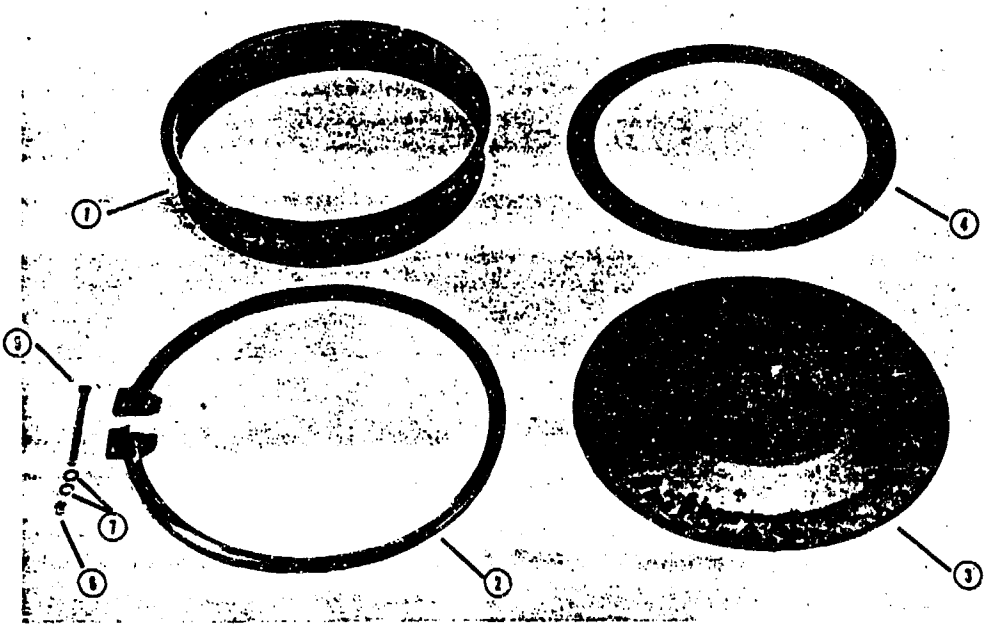
KG 20" INSPECTION MANHOLE

OVERALL HEIGHT: 3⅞" (Approximately) AVERAGE SHIPPING WEIGHT: Steel — 16 pounds Aluminum — 8 pounds

MODEL		COVER MATERIAL		WELD RING 20" ID		GASKET		VENT	
TYPE	CODE	CONTACT PARTS	EXTERNAL PARTS	CODE	MATERIAL	CODE	MATERIAL	CODE	TYPE
KG	1	Steel	Steel	1	3" Steel 12 gauge	1	Black Buna N	0	No Vent
	2	SS 304	Plated	2	Aluminum 3" x ¼"				
	3	SS 304	SS	3	3" SS 304 12 gauge				

January, 1987

KNAPPCO — KANSAS CITY, MISSOURI 64150
4304 Mattox Road Telephone:816-741-6600



KF 16" INSPECTION MANHOLE

REFERRALS	DESCRIPTION	STEEL	ALUMINUM	PLATED	304 SS	316 SS	OTHER
1	Weld Ring	1089	1090		1091	1276	
2	Clamp Ring	1107		1108	1109		
3	Cover Assembly	1266	1269		1270		
4	Gasket, Cover						1106
5	Bolt, Clamp Ring			1110	1111		
6	Nut, Clamp Ring			1114	1115		
7	Washer, Clamp Ring				1113		

KG 20" INSPECTION MANHOLE

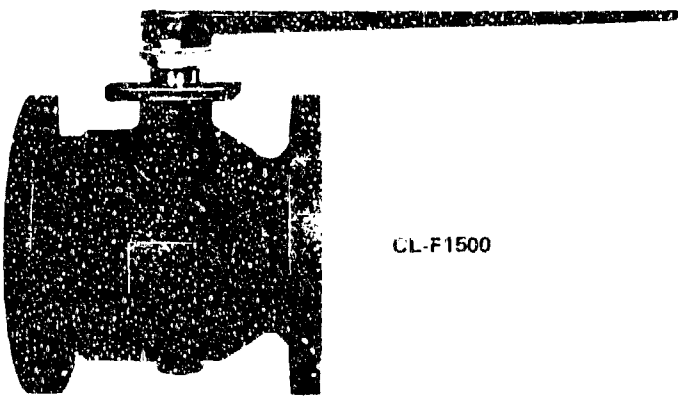
REFERRALS	DESCRIPTION	STEEL	ALUMINUM	PLATED	304 SS	316 SS	OTHER
1	Weld Ring	1175	3693		1188	1283	
2	Clamp Ring	1177		1184	3821		
3	Cover Assembly	1277			1280		
4	Gasket, Cover						1181
5	Bolt, Clamp Ring			1110	1111		
6	Nut, Clamp Ring			1114	1115		
7	Washer, Clamp Ring				1113		

BALL VALVES

F-CL-F1500

Chlorine Service BALL VALVES

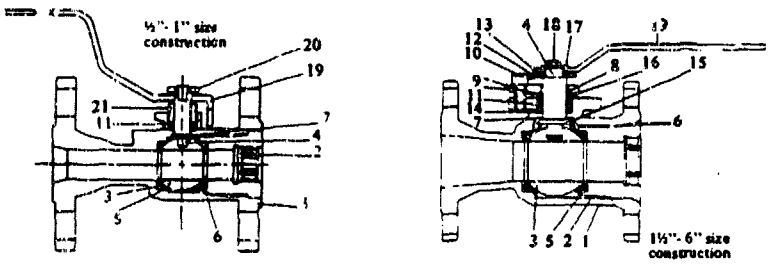
Flanged End



CL-F1500

WATTS REGULATOR Industrial Products Division

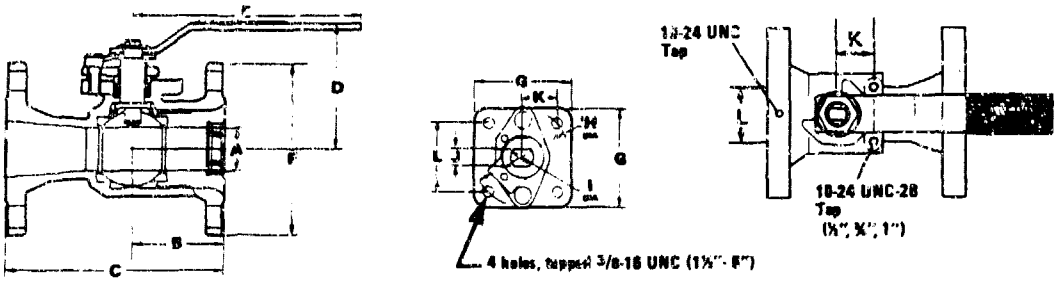
MATERIALS



CL-F1500-150-VB M/M

1. **Body** - ASTM A216-WCB Carbon Steel
2. **Seat Retainer** - C.R.S. #12L14 (½"-1"), ASTM A216 WCB Carbon Steel (1½"-up), AISI 316SS for T316 model (½"-1")
3. **Ball** - Monel
4. **Stem** - Monel
5. **Seats** - Virgin PTFE
6. **Gasket** - Virgin PTFE for Option 01 and 02.
7. **Thrust Washer** - Virgin PTFE for Option 01 and 02.
8. **Gland Sleeve** - #1018 C.R.S. (1½"-up) AISI 316SS for T316 model (1½"-up)
9. **Gland Retainer** - #1018 C.R.S. (1½"-3"); ASTM A216 WCB (4" and 6")
10. **Hex Socket Head Bolt** - Carbon Steel; AISI 304SS for T316 model (1½-up)
11. **Gland Packing** - Compressed Graphite ½"-1" (1-piece), Virgin PTFE 1½"-up (4-piece)
12. **Stopper** - #1018 Carbon Steel (1½"-up), 304SS for T316 model (1½"-up)
13. **Retaining Ring** - 304SS (1½"-up)
14. **Gland Ring** - Monel (1½"-up)
15. **Spring** - Series 300SS (1½"-up)
16. **Tape Liner** - Reinforced PTFE (1½"-up)
17. **Washer** - Cold Rolled Steel, 304SS for T316 model (1½"-up)
18. **Bolt** - Cold Rolled Steel, 304SS for T316 model (1½"-up)
19. **Handle** - Cold Rolled Steel (½"-1"), Ductile Iron (1½"-up), Series 300SS for T316 model (½"-1")
20. **Nut** - Carbon Steel (½"-1"), 316SS for T316 model (½"-1")
21. **Packing Nut** - Cold Rolled Steel (½"-1"), 316SS for T316 model (½"-1")

DIMENSIONS - WEIGHT



Size	DIMENSIONS (Inches) A	B	C	D	E	F	G	H	I	J	K	L	Weight Obs.)
½"	.50	1.58	4.25	2.38	5.11	3.50	NA	NA	.31	.19	.50	1.13	3.0
¾"	.656	2.01	4.63	3.31	5.44	3.88	NA	NA	.38	.25	.88	1.38	4.8
1"	.875	1.83	5.00	3.44	5.63	4.25	NA	NA	.50	.28	.88	1.38	6.2
1½"	1.25	3.15	6.50	3.84	10.00	5.00	3.50	3.25	.74	.37	–	–	12.8
2"	1.50	3.27	7.00	3.84	10.00	6.00	3.50	3.25	.74	.37	–	–	17.6
2½"	2.00	3.35	7.50	4.14	10.00	7.00	3.50	3.25	.74	.37	–	–	27.1
3"	2.25	3.46	8.00	4.14	10.00	7.50	3.50	3.25	.74	.37	–	–	31.5
4"	3.00	4.09	9.00	6.75	19.81	9.00	4.13	4.13	1.06	.69	–	–	64.2
6"	4.60	5.26	10.50	8.53	19.81	11.00	4.50	4.61	1.55	.69	–	–	137.0

WATTS CL-F1500 SERIES UNIBODY CONSTRUCTION ANSI FLANGED END CHLORINE SERVICE BALL VALVES

Watts CL-F1500 Series flanged end Chlorine Service ball valves are specifically designed for use on dry and wet chlorine gas generating, storage and distribution systems.

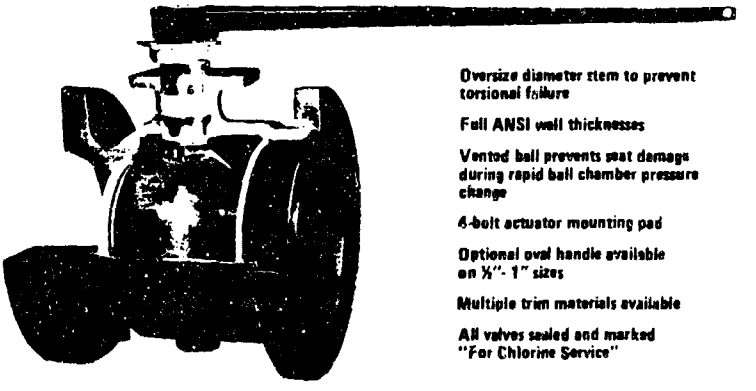
Available in ANSI 150 lb. configuration equipped with standard Monel ball and stem, these valves provide maximum safety and service life in critical chlorine environments.

Standard features include: multiple chevron style stem packing; unibody design with internal body seal; two-bolt packing adjustment; ANSI end-to-end dimensions and vented ball.

All Watts Chlorine Service ball valves are cleaned and packaged in accordance with Chlorine Institute Recommendations.

These valves also include standard locking device and 4-bolt actuator mounting pad for ease of automation. Body material is ASTM A-216 Grade WCB.

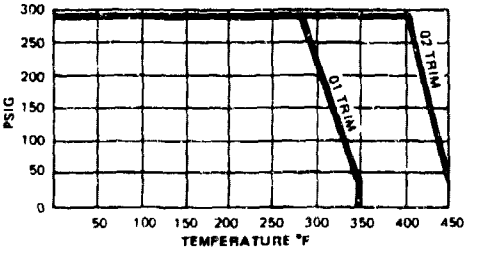
- **ANSI 150 lb. configuration**
- **Multiple Chevron Style Stem Packing**
- **2-Bolt packing adjustment isolates stem packing from handle/stem rotation**
- **Internal body seal insures end plug retention threads are isolated from corrosives**
- **Standard Monel Ball and Stem**
- **Cleaned in accordance with Chlorine Institute Recommendations**



- **Oversize diameter stem to prevent torsional failure**
- **Full ANSI wall thicknesses**
- **Vented ball prevents seat damage during rapid ball chamber pressure change**
- **4-bolt actuator mounting pad**
- **Optional oval handle available on ½"- 1" sizes**
- **Multiple trim materials available**
- **All valves sealed and marked "For Chlorine Service"**

PERFORMANCE DATA

VALVE SEAT RATING



SPECIFICATIONS

Size	CV Rating	Operating Torque (In.-Lbs.)
½"	15	60
¾"	25	90
1"	40	150
1½"	90	260
2"	150	350
2½"	290	434
3"	430	608
4"	680	730
6"	1680	3240

SPECIFICATIONS

Approved valves shall meet A.N.S.I. B16.34 and Chlorine Institute Pamphlet 6 requirements. Valve is a unidirectional ball valve with vented ball, standard virgin PTFE seats, multiple stem packing and unibody construction. Watts No. CL-F1500 or equal.

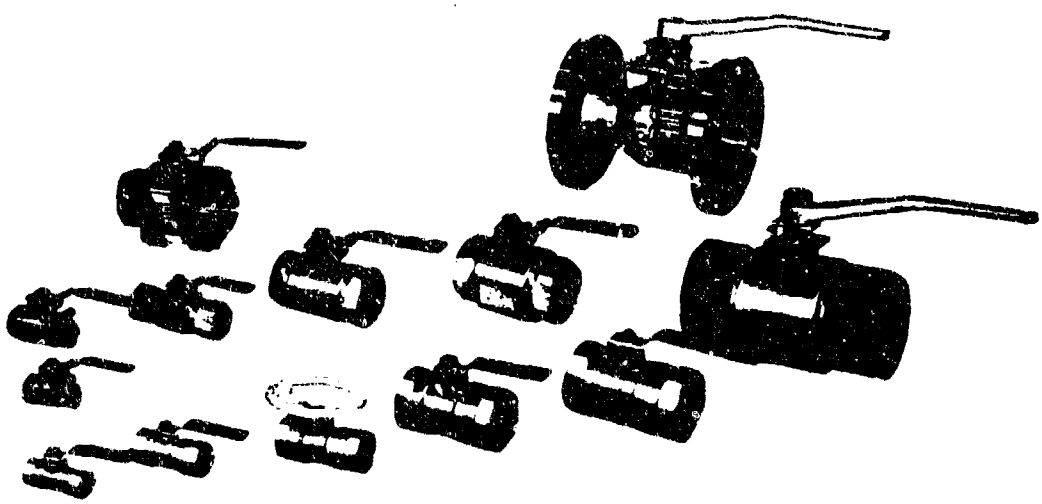
HOW TO ORDER:

2" – CL-F1500 – 150 – M/M – 01 – OL

- **Size:** ½"-6"
- **Series**
- **ANSI Class:** 150, 300
- **Ball/Stem Material:** M/M = Monel; HH = Hastelloy "B"
- **Seat/Seal Material:** 01 = PTFE; 02 = Durafill
- **Handle Option - ½"-1" Size:** OL = Oval; SH = Stainless Lever

OTHER CRITICAL SERVICE WATTS BALL VALVES:
CL-7200 - Threaded End Chlorine Service Ball Valves
SF-3500-150 - Alloy 20 Flanged Ball Valves
C-7100-M1/S-8100-M1-M/M - Unibody Ball Valves with Monel Trim

THE WATTS BALL VALVE FAMILY



WATTS REGULATOR WATTS REGULATOR COMPANY Industrial Products Division

HEADQTRS:
Box 628, Lawrence, MA 01842 (617) 688-1811
Telex: 94-7466 Watts Reg Law
International SubLsidiaries:
Watts Regulator of Canada Ltd. Telex: 06527137
Watts Regulator (Nederland) b.v. Telex: 47766

F-CL-F1500 857

PRINTED IN U.S.A.

TANK AIR VENT

"T" VENT

KNAPPCO'S "T" type vent, with standard tapered pipe threads is suitable for venting underground and above ground storage tanks.

The unit is made of aluminum and both of the openings are equipped with perforated brass screens which are held securely in place.

VE 0012 — 1"
VE 0013 — 1¼"
VE 0014 — 1½"
VE 0015 — 2"

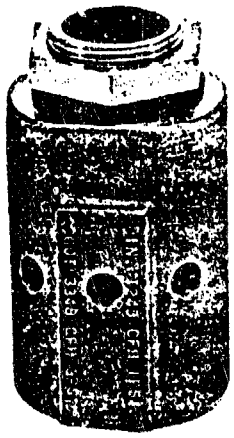
MUSHROOM VENT

The KNAPPCO Mushroom Vent is made of aluminum with standard tapered pipe threads.

The unit has a perforated brass outlet screen with a full venting area.

VE 0016 — 1½"
VE 0017 — 2"

VE 0005 VENT



COMBINATION:
VE 0006 — VE 0005

The VE 0005 Vent is a newly designed, pressure vacuum, rollover protection system which meets the most stringent field requirements. (Patent No. 4,593,711.) The design eliminates accidential venting caused by road bounce and eliminates leakage due to surge.

This Vent relieves pressure at 1 PSI and vacuum at 6 ounces per sq. inch and provides complete rollover protection from 0 to 180 degrees.

The KNAPPCO VE 0005 Vent is designed for easy cleaning and maintenance. Replacement parts and gaskets are available.

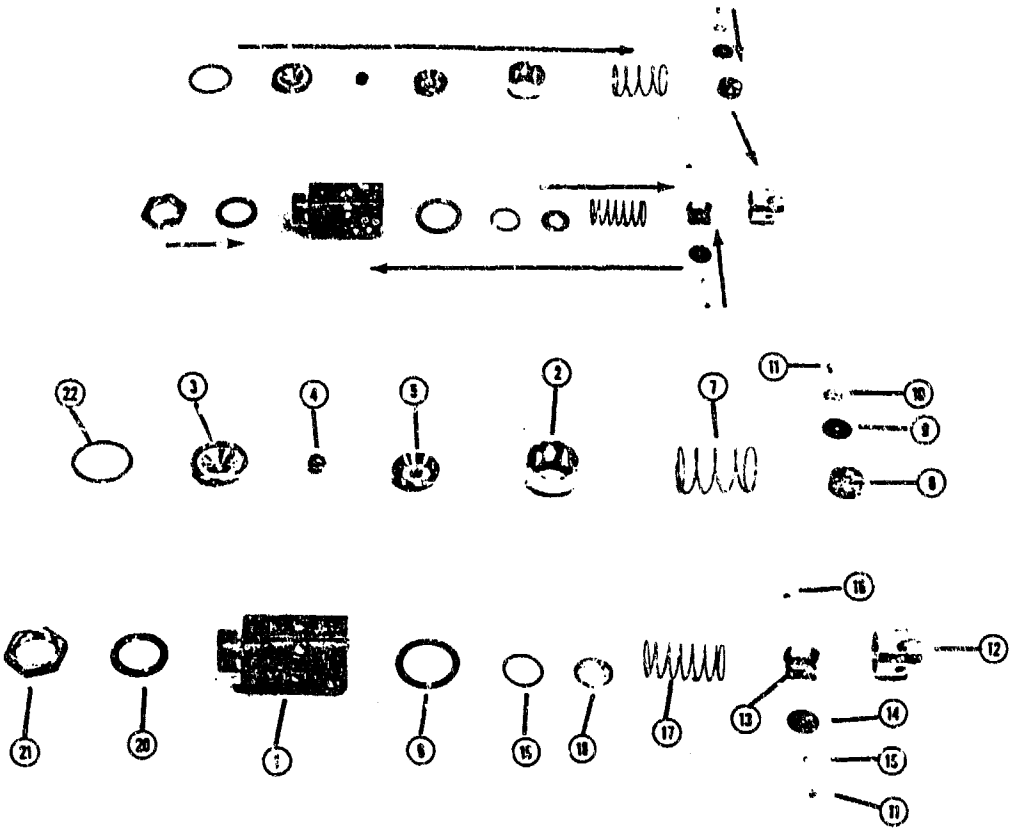
Relief capabilities of KNAPPCO 2700 Vent:

Intake — 1243 CFH @ 1 PSI
Exhaust — 3348 CFH @ 3 PSI

Thread size: 1⅝ — 12 N

January, 1987

KNAPPCO — KANSAS CITY, MISSOURI 64150
4304 Mattox Road
Telephone:816-741-6500



VE 0005

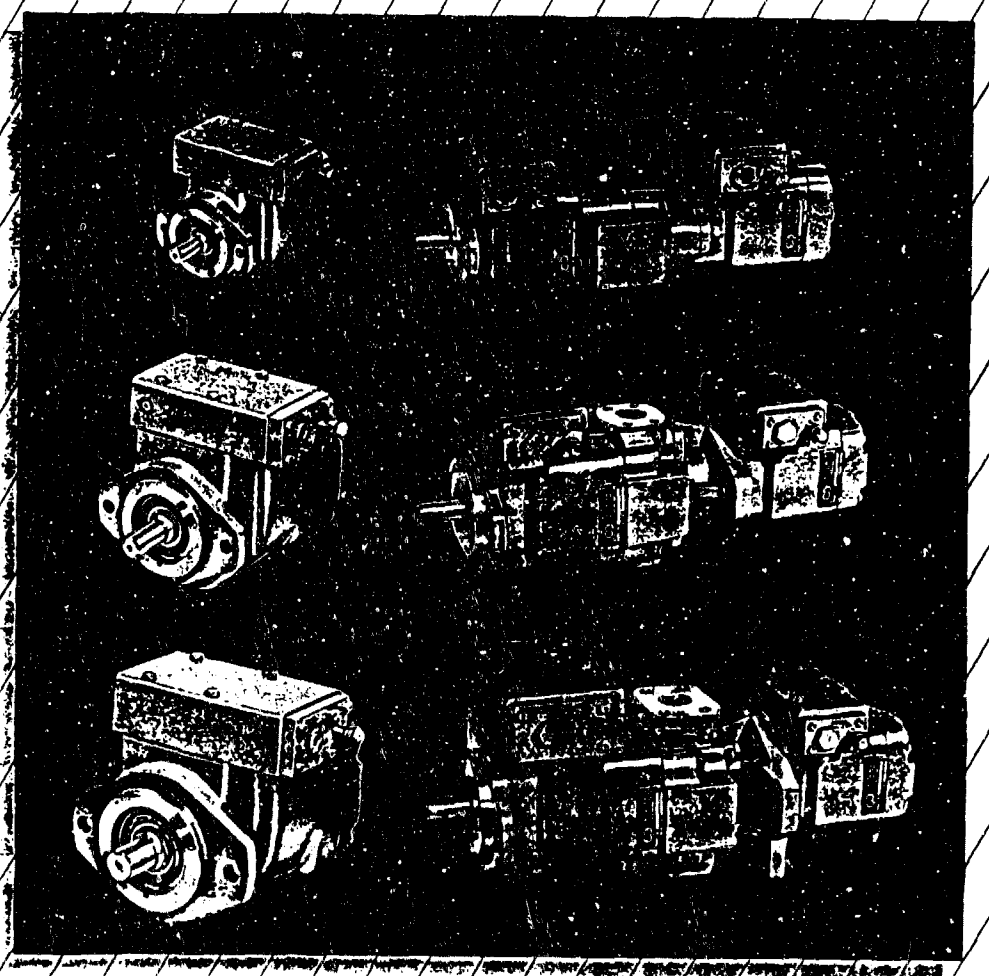
REFERRALS	DESCRIPTITN	STEEL	ALUMINUM	PLATED	304 SS	316 SS	OTHER
1	Body		2701				
2	Retainer		2720				
3	Closure, End		2709				
4	Ball				2721		
5	Actuator				2707		
6	Gasket						2710
7	Spring				2718		
8	Poppet				2711		
9	Gasket						2719
10	Retainer				2713		
11	Screw 10 - 32 x ⅜				2716		
12	Seat Valve		2703				
13	Guide				2704		
14	Gasket						2712
15	Retainer				2713		
16	Nut 10-32				3544		
17	Spring				2705		
18	Washer		2708				
19	Ring, Snap				2714		
20	Gasket						3455
21	Nut, Hex			4144			
22	Ring, Snap				2715		

HYDRAULIC PUMP

Oilgear

HYDURA

PVW
OPEN LOOP PUMPS

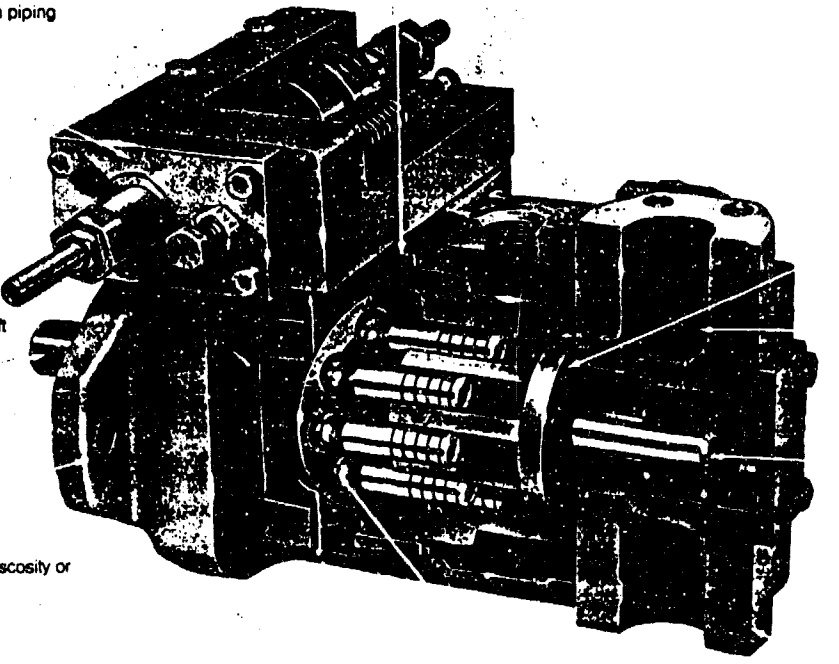


Bulletin 47014-A

PVW
OPEN LOOP PUMPS

Cylinder mounted polymerous journal bearings
- Allows operation with low viscosity or other special fluids
- Provides infinite bearing life
- Provides compact design

The industries largest control selection
- 23 different types
- Field interchangability without disconnecting from drive or system piping



SAE keyed or SAE splined shaft
- Heavy duty belt drive shafts available

Sealed front shaft bearings
- Allows operation with low viscosity or other special fluids
- Allows side loading

Steel shoes with specially treated faces for increased fluid retention, running on hardened swashblock surface.
- Allows a higher degree of contaminate resistance
- Allows higher pressure operation with long life
- Allows operation with low viscosity or other special fluids
- Provides longer life

Swashblock and saddle with special polymerous bearings
- Allows running on low viscosity or other special fluids
- Permits consistent control reaction
- Eliminates troublesome yoke bearings
- Provides long life

CONTENTS

PERFORMANCE ASSURANCE IS STANDARD WITH EVERY OILGEAR PUMP

Each Oilgear Pump manufactured is shipped with a corporate commitment to stay with the installation until the unit performs as specified.

This total dedication to performance is based upon experience gained since 1921 in matching fluid power systems to a tremendous range of machines and applications.

Oilgear's Performance Assurance is made possible because of the many hydraulic techniques learned over the years in supplying machinery builders and users with unique solutions to hundreds of unusual fluid power problems.

Historically, Oilgear has concentrated all of its energies on hydraulic equipment and systems. Every Oilgear facility is staffed with factory trained and field experienced application engineers. These men are backed by a headquarters engineering staff who has access to the records and knowledge generated from these historically successful solutions.

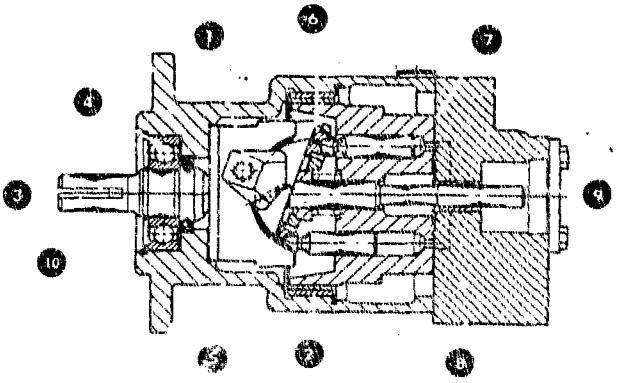
Performance Assurance doesn't stop with the design of the system or the sale of a component. It guarantees that Oilgear engineers will be there—when they are needed—supplying the education, field service, parts and repairs, to make sure each system runs smoothly—and keeps on running.

7 Hardened cylinder surface running on hardened valve plate ("hard-on-nard")
- Provides greater resistance to contamination
- Provides longer life
- Allows operation with low viscosity or other special fluids

8 Valve plate selections
- Rear or side port connections available

9 Thru-shaft availability
- Allows for multiple pump installation from a single drive shaft
- Allows pumps to drive auxiliary devices

10 Three frame sizes with seven capacity ranges allowing greater flexibility to selectively match pressure and capacity.
- Low flow/high pressure to low pressure/high flow from the same frame sizes.



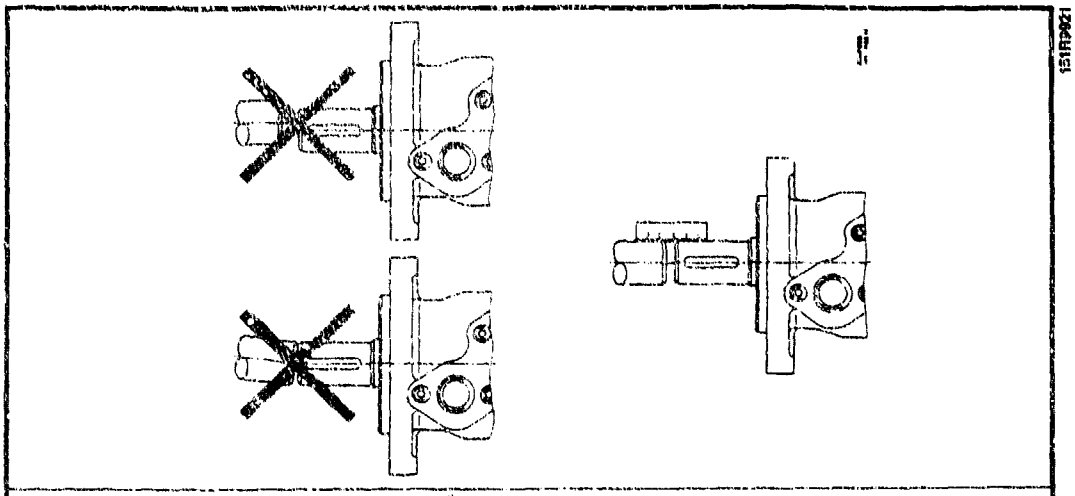
Danfoss

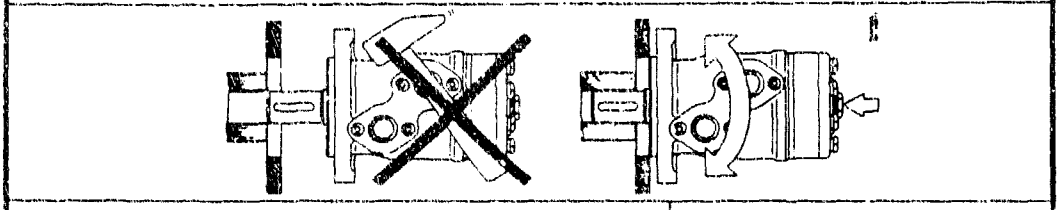
Instructions

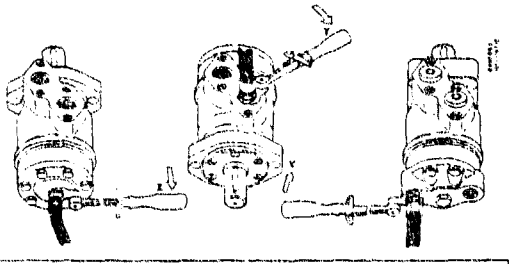
Hydraulic Motors

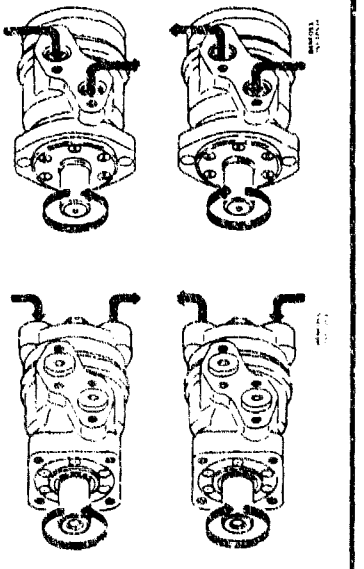
OMP, OMPW, OMPA and OMPAW

151R9221









	Max. tilspændingsmoment Max. tightening torque Max. Anzugsmomen. Couple de serrage max.			
	X		Y	
Forskruning Screwed connection Verschraubung Raccord	¼ BG ¼ BSPF R ¼ G ¼	7/16-20 UNF	¼ BG ¼ BSPF R ¼ G ¼	9/16-14 UNF
med stålskive with steel washer mit Stahlscheibe avec rondelle en acier	4 daNm (350 lbf in)		13 daNm (1150 lbf in)	
med aluminiumsskive with aluminium washer mit Aluminiumscheibe avec rondelle en aluminium	3 daNm (270 lbf in)		7 daNm (620 lbf in)	
med skærekant with cutting edge mit Dichtkante tranchant	4 daNm (350 lbf in)		13 daNm (1150 lbf in)	
med o-ring with o-ring mit O-Ring avec joint torique		2 daNm (180 lbf in) (180 in-lbs)		9 daNm (795 lbf in) (795 in-lbs)

Hydraulic motor OMP

Code numbers and weight

			OMP 50	OMP 80	OMP 100	OMP 160	OMP 200	OMP 250	OMP 315	OMP 400	Base block*
Motor with cylindrical shaft	1 inch		151-0000	151-0001	151-0002	151-0003	151-0004	151-0048	151-0005	151-0006	151-1100
	25 mm		151-0028	151-0029	151-0030	151-0031	151-0032	151-0049	151-0033	151-0027	151-1100
Motor with splined shaft			151-0035	151-0036	151-0037	151-0038	151-0039	151-0050	151-0041	151-0034	151-1100
Weight		(lb)	12.3	12.5	13.1	13.6	14.1	14.8	15.2	16.3	3.3

* Base block for OMP/OMR. Mounting set incl.

Technical data

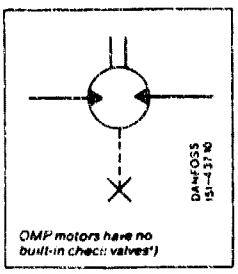
UK-units

			OMP 50	OMP 80	OMP 100	OMP 160	OMP 200	OMP 250	OMP 315	OMP 400
Geometric displacement	(in³)		2.96	4.75	5.94	9.50	11.87	14.78	18.67	23.75
Max. speed	(r/min)	cont.	800	750	600	400	310	250	205	160
		int.[1]	1000	940	750	500	390	310	255	200
Max. torque	(lbf in.)	cont.	530	840	1060	1750	2100	2500	2300	2300
		int.[1]	750	1200	1500	2300	3000	3300	3300	3400
		peak[2]	1200	1900	2400	3800	4800	4900	5300	5300
Max. output	(hp)	cont.	7	8	9.5	9.5	8	8.5	5.8	4
		int.[1]	8	12	13.5	13.5	12	10.5	8	7
Max. pressure drop	(lbf/in²)	cont.	1450	1450	1450	1450	1450	1400	1000	800
		int.[1]	2000	2000	2000	2000	2000	1800	1450	1150
		peak[2]	3300	3300	3300	3300	3300	2600	2300	1800
Max. oil flow	(g.p.m., U.K.)	cont.	6.6	13.2	13.2	13.2	13.2	13.2	13.2	13.2
		int.[1]	11.0	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Max. inlet pressure	(lbf/in²)	cont.	2000	2000	2000	2000	2000	2000	2000	2000
		int.[1]	2500	2500	2500	2500	2500	2500	2500	2500
		peak[2]	3300	3300	3300	3300	3300	3300	3300	3300
Max. pressure on the shaft seal (without drain line)[3] or Max. pressure in drain line	(lbf/in²)	cont. 0-100 r/min	1100	1100	1100	1100	1100	1100	1100	1100
		cont. 100-300 r/min	725	725	725	725	725	725	725	725
		cont. > 300 r/min	365	385	365	365	365	365	365	365
		int.[1] 0-max. r/min	1100	1100	1100	1100	1100	1100	1100	1100
Max. return pressure with drain line	(lbf/in²)	cont.	2000	2000	2000	2000	2000	2000	2000	2000
		int.[1]	2500	2500	2500	2500	2500	2500	2500	2500
		peak[2]	3300	3300	3300	3300	3300	3300	3300	3300
Max. starting pressure with unloaded shaft	(lbf/in²)		150	150	150	100	75	75	75	75
Min. starting torque	(lbf in)	at max. press. drop cont.	440	750	975	1600	2000	2200	2300	2300
		at max. press. drop int.	820	1050	1400	2200	2600	3200	3200	3300

[1] Intermittent operation: the permissible values may occur for max. 10% of every minute.
[2] Peak load: the permissible values may occur for max. 1% of every minute, see "Continuous operation/intermittent operation/peak load", page 65.
[3] The pressure on the shaft seal is calculated as the average between the inlet and return pressures:

$$\frac{p_1 + p_2}{2}$$

[4] See "Max. pressure on the shaft seal", page 71.



OMP motors have no built-in check valves[4])

Pressure loss curves for Danfoss hydraulic motors can be found on page 74.

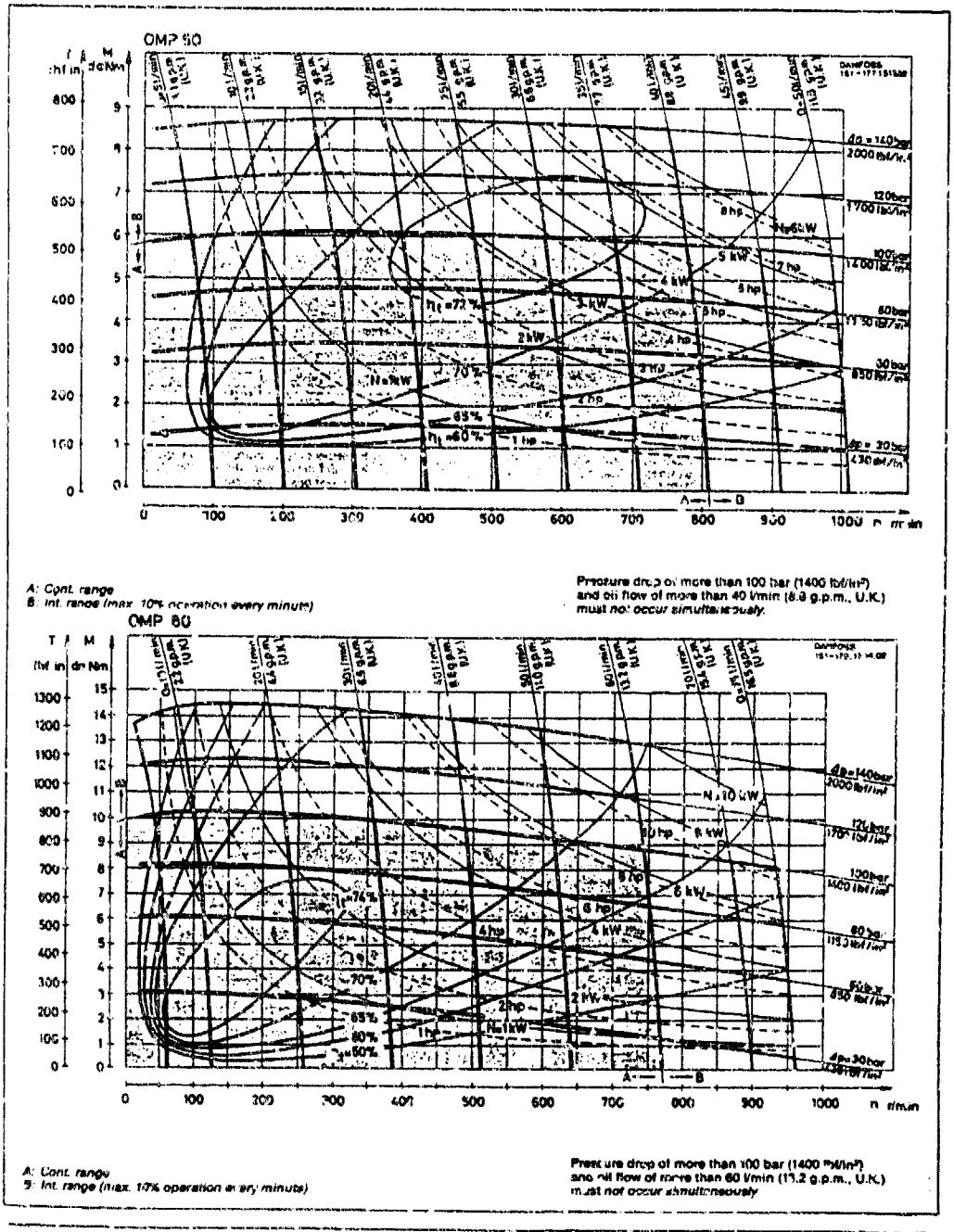
Function diagrams

The following function diagrams are for use as described in the section "Selection of hydraulic motor", page 65.

The diagrams are drawn on the basis of function tests on a representative number of motors from our production.

The diagrams apply to mineral based hydraulic oil with a viscosity of 35 cSt and a temperature of 50°C.

Operation at less than 5-10 r/min will be slightly less smooth.
See "Min. speed", page 67.



Colorflow Series MV and MVB Needle Valves and Throttling Valves

These high-precision metering and shutoff valves allow extremely close control of fluids used in actuating and governing many types of mechanisms and equipment. Exclusive "Colorflow" scale on the valve stem simplifies returning the valve to a previous setting, conserves time lost in hunting for this setting. Bi-directional flow.

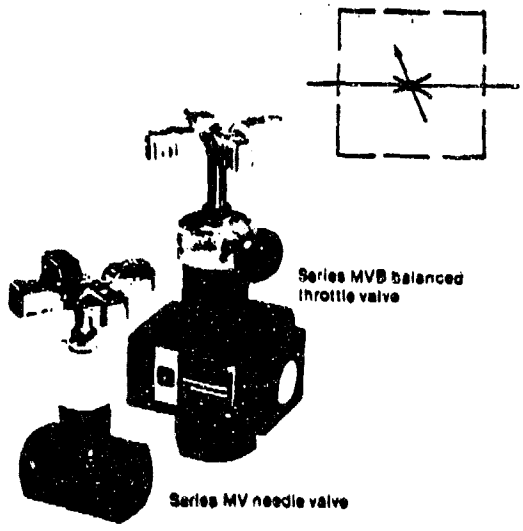
One standard and two optional needle designs for the 1/8" and 1/4" MV valves permit a wide range of flow-rate control.

Series MV Valves are offered in brass or steel. Needles are stainless steel. Choice of angle or in-line designs and all standard port connections.

Maximum operating pressure:
Steel: 5000 PSI (345 Bar) for Models MV200 through MV1220; 3000 PSI (210 Bar) for Models MV1600 and MVBF 1600-3200.

Brass: 2000 PSI (140 Bar)

Needles:
Standard, all models: 30° taper; Optional, MV200 and MV400 only: Dash 2: Fine. Dash 3: Micro-fine.



Series MVB balanced throttle valve

Series MV needle valve

Quick Reference Data Chart

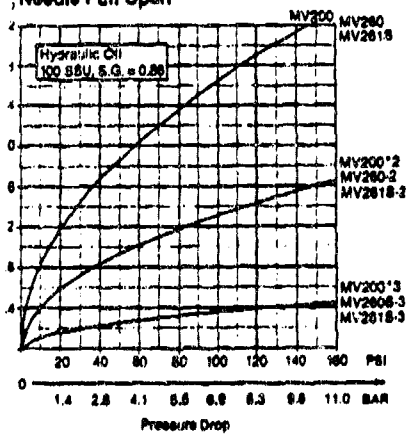
Model Number	Port Size, in. NPTF	Flow, Max. GPM (L/M)	Pressure at Max. Flow PSI (Bar)	Orifice Area, in² Full Open	C_v Factor
MV200 *	1/8	3 (11)	200 (14)	0.0107	0.244
MV200-2	1/8	1.8 (7)	200 (14)	.0053	.121
MV200-3	1/8	0.5 (2)	200 (14)	.0014	.032
MV400 * MV820 *	1/4	5 (19)	130 (9)	.0216	.493
MV400-2	1/4	2.8 (11)	200 (14)	.0081	.186
MV400-3	1/4	0.5 (2)	200 (14)	.0017	.039
MV600 * MV820 *	3/8	8 (30)	35 (2.5)	.0567	1.294
MV800 * MV1020 *	1/2	15 (57)	48 (3)	.0845	1.930
MV1200 * MV1220 *	3/4	25 (95)	52 (4)	.140	3.205
MV1600 *	1	40 (151)	98 (7)	.1675	3.829
MVBF1600	1**	65 (246)	100 (7)	0.308	7.0
MVBF2400	1-1/2**	230 (871)	100 (7)	0.963	22.0
MVBF3200	2**	300 (1136)	65 (5)	1.53	35.0

*Coast Guard Acceptance - Steel.
**Machined for SAE flange.

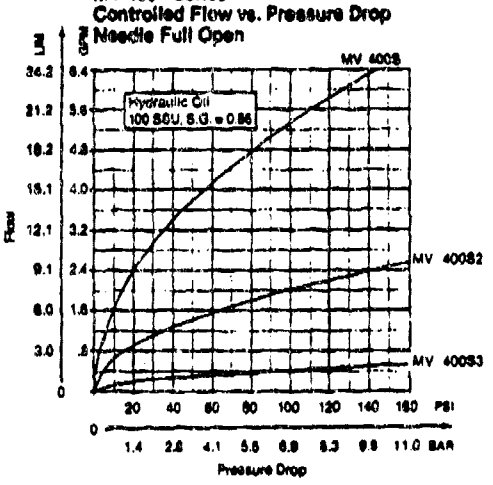
For additional information — call your Parker Sales Office (see listing on page VI).

rmance

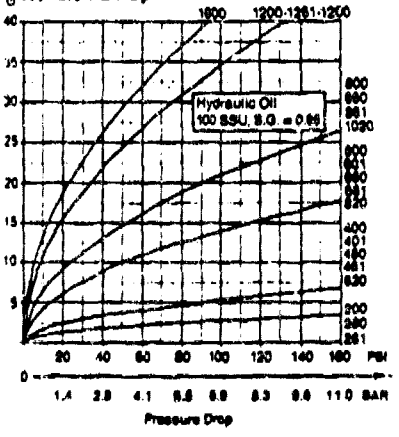
MV 200° Series
Controlled Flow vs. Pressure Drop
Needle Full Open



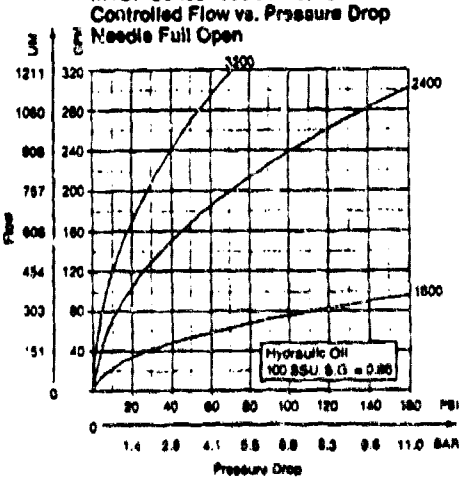
MV 400° Series
Controlled Flow vs. Pressure Drop
Needle Full Open



MV 200 thru 1600 Series
Controlled Flow vs. Pressure Drop
Needle Full Open



MVBF Series 1600 thru 3200
Controlled Flow vs. Pressure Drop
Needle Full Open



LEVEL AND TEMPERATURE SWITCHES

— LEVEL SWITCH —
HIGHEST PERFORMANCE RATING

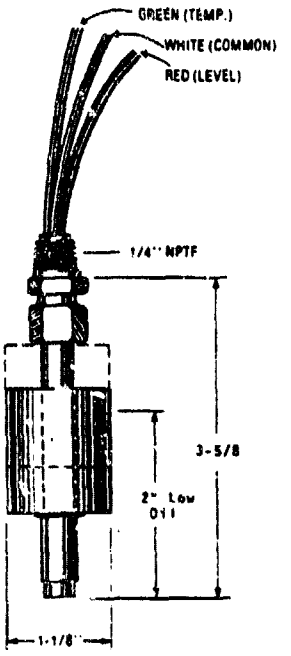
THE "LH" SERIES LEVEL SWITCHES WILL CONTINUOUSLY CARRY 5.0 AMPS AND WILL SWITCH UP TO *3.0 AMPS.

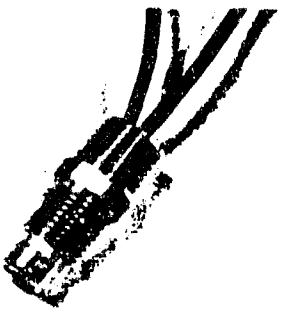
--- RELAYS CAN BE ELIMINATED IN MANY INSTANCES ---

- VOLTAGE - 5 TO 240 VAC, DC
- BREAKDOWN - 400 VRMS MIN.
- CAPACITANCE - 1.0 PICOFARAD
- INSULATION RESISTANCE - 1X10 OHMS
- INITIAL CONTACT RESISTANCE - 500 MILLPHMS

- LEVEL SENSITIVITY - -.050
- OPERATING PRESSURE - 50 PSI MAX.
- FLUID COMPATIBILITIES - ANY FLUID (EXCEPT STRONG HYDROCARBON SOLVENTS)
- FAIL SAFE - UNIT WILL OPERATE CONTINUOUSLY IN FREE AIR WITH NO DAMAGE
- SWITCH MODE - LH-013 NORMALLY OPEN (FLOAT UP)
  LH-012 NORMALLY CLOSED (FLOAT UP)
- MOUNTING - 1/4 NPT THROUGH TOP OR BOTTOM IN VERTICAL POSITIONS

*WHEN SWITCHING EXCESSIVE HIGH INDUCTIVE AND LAMP LOADS CONSULT FACTORY FOR PROPER RECOMMENDATIONS AND/OR TESTING THE COMPATABILITY OF COMPONENTS.





TEMPERATURE CONTROL

6 AMPS 120V, 4 AMPS @ 240VAC-DC - NON INDUCTIVE
FOR RATINGS UP TO 50 AMPS AND 5000 PSI, CONTACT FACTORY

U.L. RECOGNIZED, FILE E-37151 "COMPONENT-TEMPERATURE AND REGULATING CONTROL" CSA LISTINGS, FILE LR22873 "INDUSTRIAL CONTROL EQUIPMENT - MOTOR CONTROLLERS - MISCELLANEOUS"

MODEL NO. T22-4 - 1/4 NPT, BRASS, NORM.CLOSED
MODEL NO. T23-4 - 1/4 NPT, BRASS, NORM.OPEN

TEMP.SETTINGS ARE 35 C (95 F) TO 115 C (239 F) IN 5 C INCREMENTS FOR OTHER TEMP SETTINGS FROM 38 F TO 350 F AND FOR 2 OR 3 SWITCHES IN A SINGLE 1/2 NPT HOUSING - CONTACT FACTORY.

TEMPERATURE & LEVEL SENSOR
"NEW" HIGHER RATING

"LEVEL" CONTACT RATING - NON INDUCTIVE

CARRY	- 3.0 AMPS MAX. @ 110 VAC - DC 300 WATTS @ 110 VAC - DC
BREAK	- 1.1 AMP MAX. @ 110 VAC - DC 3.0 AMPS ON MODELS "LH"
VOLTAGE	- 5 V TO 220 VAC OR DC

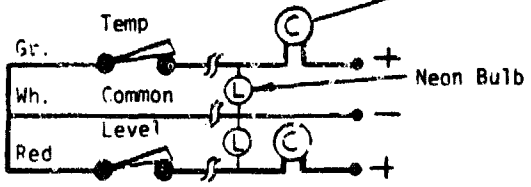
"TEMPERATURE" CONTACT RATING - NON INDUCTIVE
NORMALLY OPEN OR CLOSED

CARRY	- 12 AMPS
MAKE OR BREAK	- 6 AMPS
AUTO RE-SET	- WITH 3 C.
TEMP.SETTINGS	- 35 C. (95 F.) TO 115 C. (239F.) IN 5 C. INCREMENTS
TEMP.OPTION "LL" OPTION	- TO TURN ON A "HEATER" IN COLD WEATHER USE (5 C.) 38 F. SETTING

FOR SEPARATE INDICATION OF "TEMPERATURE" AND "LEVEL" CONNECT WIRES IN PARALLEL AS SHOWN.

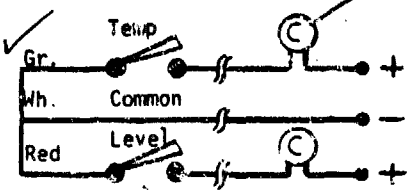
FOR SINGLE INDICATION OF BOTH "TEMPERATURE" AND, "LEVEL", CONNECT IN SERIES AS SHOWN.

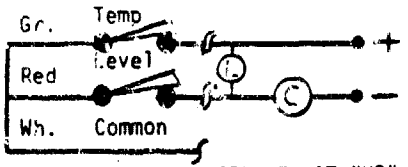
INDICATOR, STARTER COIL, ETC.



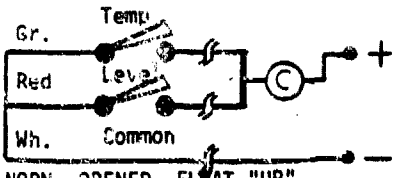
Neon will light when switch opens

LIGHT, BUZZER OR RELAY, ETC.





TL-008 NORM. CLOSED, FLOAT "UP"



TL-009 NORM. OPENED, FLOAT "UP"

APPROVED PURIFICATION CORP., 608 ATLANTIC STREET, STAMFORD, CT. 06902, 203-357-0141

BLACKMER POWER PUMP

BLACKMER POWER PUMPS

INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS

MODELS: GX, GXS, X, XS
2, 2½, 3, 4
(Includes Model XU2)

960210
INSTRUCTION NO. 188/C

Section	100
Effective	November 1988
Replaces	May 1982

WARNING

THIS PRODUCT MUST ONLY BE INSTALLED IN SYSTEMS WHICH HAVE BEEN DESIGNED BY THOSE QUALIFIED TO ENGINEER SUCH SYSTEMS. THE SYSTEM MUST BE IN ACCORDANCE WITH ALL APPLICABLE REGULATIONS AND SAFETY CODES AND WARN OF ANY HAZARDS UNIQUE TO THE PARTICULAR SYSTEM.

INSTALLATION

CLEANING PRECAUTIONS

New tanks require careful cleaning to remove weld splatter, slag, scale and other foreign matter before filling with liquid. Suction pipes from the tank to the pump should be flushed before being attached to the pump.

LOCATION

Locate the pump as near the source of supply as possible to reduce detrimental inlet pipe friction. A solid foundation reduces vibration and noise and improves the pump performance. On permanent installations it is recommended that the pumping units be securely bolted to a concrete foundation.

FOUNDATION

When new pump foundations are to be cast in concrete, it is suggested that anchor bolts of the type shown in Fig. 1 be set into the concrete.

This type of anchor bolt allows for slight shifting of position to better line up with the mounting holes in the base plate. When pumps are to be located on existing concrete floors, holes should be drilled into the concrete and foundation bolts anchored therein.

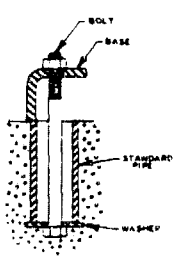


Fig. 1

When installing units built on channel or structural steel type bases, care should be taken that the base is not twisted out of shape when anchor bolts are tightened. Shims should be used under the edges of the base prior to tightening of the anchor bolts to prevent distortion.

PIPING

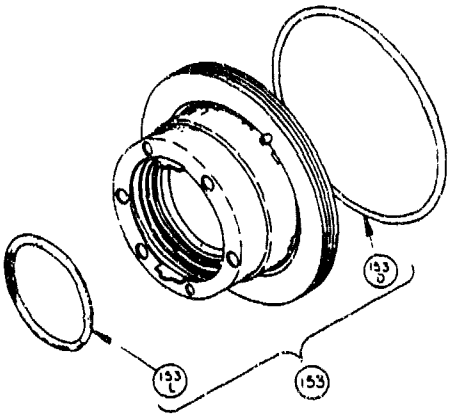
Many pump systems deliver at a rate below the designated capacity of the pump because the system was improperly piped. Before installing any piping, a complete piping diagram should be made, and pipe friction, suction lift, discharge head, vacuum and total pressure on the pump should be computed for the specific liquid being handled, and the desired flow rate. Without these computations it is almost impossible to determine beforehand whether a pumping installation will work properly.

Restrictions in the pipe line, such as elbows, sharp bends, globe valves, certain restrictive-type plug valves and undersized strainers, should be avoided. Use gate or ball valves, not globe valves. The inlet line should be at least as large as the intake port, and as straight as practical. It should slope downward to the pump, never upward or with upstanding loops. Use pipe of adequate size and strength that has been thoroughly flushed prior to being connected to the pump. Expansion joints, placed at a minimum of three feet (0.91 meters) away from the pump, will compensate for expansion and contraction.

It is very important that there be no air leaks in the intake line. If practical to do so, apply air pressure to the completed pipe line to check for leaks.

The use of check valves or foot valves in the supply tank is generally not recommended with a self-priming, positive displacement pump and can often cause considerable trouble. If a valve in the discharge line is closed while the pump is operating it forces liquid to recirculate through the pressure relief valve causing the liquid to heat up and expand. A check valve in the suction line prevents the expanding liquid from returning to the supply tank, causing a build-up of pressure on the pump and in the piping system. The result can be excessive leakage at the pump or at the pipe joints. If a check valve is required, locate it near the pump on the discharge side only.

PARTS LIST NO. 185/C10



X2A, X2 - MECHANICAL SEAL - STANDARD

REF. NO.	PART NAME	PARTS PER PUMP	X2A PART NO.	X2 PART NO.
153	Mechanical Seal Complete, Cast Iron Stationary Seat, Carbon Seal Face, Buna-N O-Rings.	2	331601	331415
153D	O-Ring - Stationary (Buna-N)	2	701934	701934
153L	O-Ring - Rotating (Buna-N)	2	701922	701920

X2A, X2 - MECHANICAL SEAL - OPTIONAL

REF. NO.	PART NAME	PARTS PER PUMP	X2A PART NO.	X2 PART NO.
153	Mechanical Seal Complete, Cast Iron Stationary Seat, Bronze Seal Face, Buna-N O-Rings.	2	331604	331411
153D	O-Ring - Stationary (Buna-N)	2	701934	701934
153L	O-Ring - Rotating (Buna-N)	2	701922	701920

XS2A, XS2 - MECHANICAL SEAL - STANDARD

REF. NO.	PART NAME	PARTS PER PUMP	XS2A PART NO.	XS2 PART NO.
153	Mechanical Seal Complete, Cast Iron Stationary Seat, Buna-N O-Ring, Carbon Seal Face with Teflon Seal Ring.	2	*331602	*331430
153D	O-Ring - Stationary (Buna-N)	2	701934	701934
153L	Seal Ring - Rotating (Teflon)	2	**	**

XS2A, XS2 - MECHANICAL SEAL - OPTIONAL

REF. NO.	PART NAME	PARTS PER PUMP	XS2A PART NO.	XS2 PART NO.
153	Mechanical Seal Complete, Cast Iron Stationary Seat, Carbon Seal Face with Viton O-Rings.	2	331655	331455
153D	O-Ring - Stationary (Viton)	2	701921	701921
153L	O-Ring - Rotating (Viton)	2	701980	701979

XS2A, XS2 - MECHANICAL SEAL - OPTIONAL

REF. NO.	PART NAME	PARTS PER PUMP	XS2A PART NO.	XS2 PART NO.
153	Mechanical Seal Complete, Cast Iron Stationary Seat, Bronze Seal Face, Viton O-Rings.	2	331623	331457
153D	O-Ring - Stationary (Viton)	2	701921	701921
153L	O-Ring - Rotating (Viton)	2	701980	701979

XS2A, XS2 - MECHANICAL SEAL - OPTIONAL

REF. NO.	PART NAME	PARTS PER PUMP	XS2A PART NO.	XS2 PART NO.
153	Mechanical Seal Complete, SS Stationary Seat, Carbon Seal Face, Viton O-Rings.	2	331654	331454
153D	O-Ring - Stationary (Viton)	2	701921	701921
153L	O-Ring - Rotating (Viton)	2	701980	701979

XS2A, XS2 - MECHANICAL SEAL - OPTIONAL

REF. NO.	PART NAME	PARTS PER PUMP	XS2A PART NO.	XS2 PART NO.
153	Mechanical Seal Complete, SS Stationary Seat, Buna-N O-Rings, Carbon Seal Face with Teflon Seal Ring.	2	331650	331450
153D	O-Ring - Stationary (Buna-N)	2	701934	701934
153L	Seal Ring - Rotating (Teflon)	2	**	**

XS2A, XS2 - MECHANICAL SEAL - OPTIONAL

REF. NO.	PART NAME	PARTS PER PUMP	XS2A PART NO.	XS2 PART NO.
153	Mechanical Seal Complete, Cast Iron Stationary Seat, Teflon O-Ring, Carbon Seal Face with Teflon Seal Ring.	2	331675	331475
153D	O-Ring - Stationary (Teflon)	2	702056	702056
153L	Seal Ring - Rotating (Teflon)	2	**	**

* Parts Included in Pump Repair Kit.
** Teflon Seal Ring is not available as a separate part.

blackmer / A DOVER RESOURCES COMPANY
1809 Century Avenue, Grand Rapids, Michigan 49509, U.S.A. • (616) 241-1611 • Telex: 4320148 • Fax: (616) 241-3752

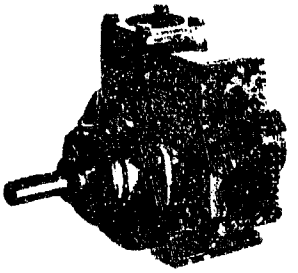
BLACKMER PUMP PARTS LIST

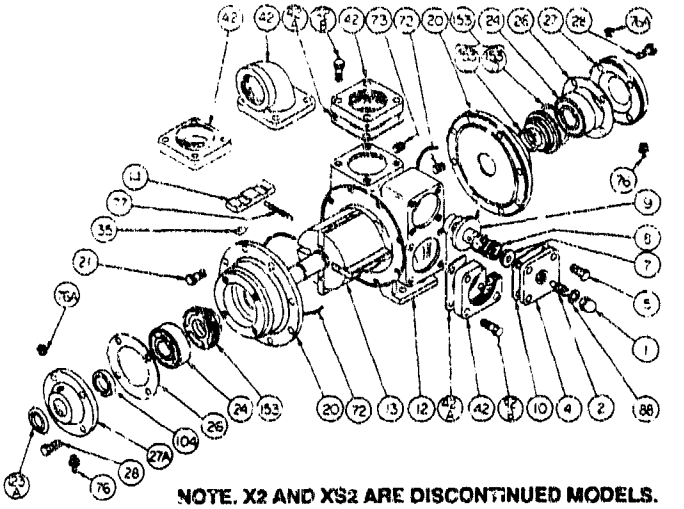
MODELS: X2A, XS2A

(See Instructions 185/C for Operation and Maintenance)

960216
PARTS LIST NO. 185/C2

Section	100
Effective	January 1991
Replaces	November 1988





NOTE. X2 AND XS2 ARE DISCONTINUED MODELS.

REF. NO.	PART NAME	PARTS PER PUMP	X(S)2A PART NO.	X(S)2 PART NO.	REF. NO.	PART NAME	PARTS PER PUMP	X(S)2A PART NO.	X(S)2 PART NO.
1	Cap - Relief Valve (R/V)	1	411452	411452	20	Head	2	031425	031425
2	Adjusting Screw - R/V	1	431401	431401	21	Capscrews - Head	16	920331	920331
4	Cover - R/V	1	411401	411401	24	Ball Bearing	2	*903196	*903158
5	Capscrew - R/V Cover	4	920316	920316	26	Gasket - Bearing Cover	1	*383940#	*383940#
7	Spring Guide - R/V	1	423955	423955	27	Bearing Cover - Outboard	1	041433	041433
8	Spring - R/V (25-36 psi)	1	471412	471412	27A	Bearing Cover - Inboard	1	041431	041431
	Spring - R/V (36-50 psi)		471415	471415	28	Capscrews - Bearing Cover	8	920285	920285
	Spring - R/V (61-75 psi) (Std.)		*471420	*471420	35	Key - Shaft	1	*909150	*909130
	Spring - R/V (76-110 psi)		471425	471425	42	Flange - 1¼" NPT	1 - 2	651412	651412
	Spring - R/V (111-125 psi)		471428	471428		Flange - 2" NPT		651411	651411
	SS Spring - R/V (36-50 psi)[1]		471417	471417		Flange - 2" Weld		654405	654405
	SS Spring - R/V (61-75 psi)[1]		471418	471418		Flanged Elbow - 2" NPT		651415	651415
	SS Spring - R/V (76-110 psi)[1]		471427	471427	42A	Gasket - Flange	2	*381465#	*381405#
	SS Spring - R/V (111-125 psi)[1]		471429	471429	42B	Capscrew - NPT/Weld Flange	4 - 8	920339	920351
9	Valve - R/V (Std.)	1	*451417	*451417		Capscrew - Flanged Elbow		920331	920331
	Valve - R/V (Nickel Plated)		451415	451415	72	O-Ring - Head (Buna-N) (Std.)	2	*701947#	*701947#
10	Gasket - R/V Cover	1	*531403#	*531403#		O-Ring - Head (Viton)		701914	701914
12	Cylinder	1	021403	021403		O-Ring - Head (Teflon)		702091	702091
13	Rotor & Shaft	1	261418	221455	73	Gage Plug	2	908195	908195
	EC Rotor & Shaft		261412	221449	76	Grease Fitting	2	317815	317815
14	Vane - Duravane (Std.)	4	*091419	*091419	76A	Grease Relief Fitting	2	701992	701992
	Vane - Bronze		093922	093922	77	Push Rod	2	*123905	*123905
	Vane - EC Bronze		093924	093924	88	Gasket - R/V Cap	1	*701981#	*701981#
	Vane - Cast Iron		093921	093921	104	Grease Seal	1	*331918#	*331918#
	Vane - EC Cast Iron		093923	093923	123A	Dirt Shield	1	701480	701480
	Vane - Laminate		091427	091427		Pump Repair Kit (XS)		891182	891171
	Vane - EC Laminate		091429	091429		Gasket Repair Kit		891455	891455

[1]Available for XS Models only. * Parts Included in Pump Repair Kit. # Parts Included in Gasket Repair Kit.

Note: Viton and Teflon are Registered Trademarks of E.I. DuPont.

Note: An X(S)2 Model can be upgraded to an X(S)2A Model by replacing the Rotor & Shaft (Ref. No. 13), the Bearing (Ref. No. 24), and the Mechanical Seal (Ref. No. 153) – must be replaced as a group.

STRAINER

A strainer is recommended to protect the pump from damage by foreign particles. Generally, the strainer should be installed in the inlet line, close to the pump, and should have a net open area of at least four times the area size of the pump intake pipe. For more specific applications, refer to the manufacturer's recommendation for proper installation and sizing of the strainer. The strainer should be inspected and cleaned at regular intervals.

ALIGNMENT

The alignment of the motor, the gear reducer, and the pump is often disturbed in transit and must be checked before the unit is put into operation.

On units where flexible couplings are used, the coupling guard should be removed and a straight edge laid across the two hubs of the coupling, as shown in Fig. 2. The maximum offset should be less than .015" (0.381mm).

Fig. 2 — Alignment Check

With a feeler gauge, or piece of flat steel of proper thickness, check the angular alignment of the coupling halves. Check in four places at 90 degree increments about the periphery of the coupling. Maximum variation in this spacing should not exceed .020" (0.508mm). Misalignment is not desirable. If it does exist, it should not exceed the above limits.

Check the alignment of the pipes to the pump to avoid strains which might later cause misalignment. To check, unbolt flanges or break union joints. Pipes should not spring away or drop down. After pumps have been in operation for a week or two, completely recheck alignment.

GEAR REDUCER ALIGNMENT — GX(S) ONLY

The reducer can be rotated on its mounting to raise or lower the input shaft to facilitate alignment to the motor shaft. First, loosen the four clamp cap screws and two setscrews in the spool flange. The reducer is then free to rotate. If it sticks, tap it with a mallet. To align the reducer, check the alignment of the two halves of the coupling.

ROTATION

On the X(S) pumps, a right-hand pump rotates clockwise with the intake on the right side when viewed from the driven end.

On the GX(S) pumps, a right-hand pump also rotates clockwise with the intake on the right side when viewed from the driven end. However, due to the gear reducer, the reducer input shaft will rotate counterclockwise.

TO REVERSE PUMP ROTATION

On X(S) pumps, remove the head from the shaft side and reverse the rotor and shaft so that the shaft protrudes through the head still on the cylinder. On GX(S) pumps, both heads should be removed, and the cylinder reversed.

On both the X(S) and the GX(S) pumps, the vanes must also be reversed in their slots so that the pressure relief grooves face in the direction of rotation. The rounded or wearing edge of the vanes must be outward to contact the bore of the cylinder. See "Maintenance" for removal and replacement of the pump parts.

OPERATION

PUMP PERFORMANCE CHECK

It is usually desirable to make a running check of a pumping system before putting it into operation. The main points to check include: general operation of the system, leakage from piping and equipment, direction of pump rotation, proper pump speed, noise level of the pump, pumping rate, and shut-off pressure.

Whenever a new pump is first started, it should be watched carefully for several hours and checked for signs of malfunction.

If the pump is abnormally noisy, follow the checking procedures outlined under "Pump Troubles and Their Cures."

RUNNING PUMP IN REVERSE

It is sometimes desirable to reverse the pump for draining a line. The pump is satisfactory for this type of operation if a separate pressure relief valve is provided to protect the pump from excessive pressures. When pumping backwards against a possible closed valve, operation in reverse may cause an increase in noise and vibration.

FLUSHING THE PUMP

Liquids which solidify when cold or which might otherwise damage the pump after prolonged contact should be flushed out.

Drain the pump and lines by pumping air. Then pump flushing liquid to suitably clean the pump. Close the discharge line for 30 second intervals (maximum) while pumping. This should be done a few times to flush out the relief valve.

RELIEF VALVE

The pressure setting or range for which the relief valve is set, is marked on a metal tag attached to the relief valve cover. The relief valve should normally be set 15 psi (100 kPa) higher than the operating pressure

To increase the pressure setting, remove the relief valve cap from the adjusting screw, loosen the locknut and turn the adjusting screw clockwise, or inward. To reduce the pressure setting, turn the screw counterclockwise, or outward. Springs for higher or lower pressure settings are available. (See individual parts lists for relief valve spring part numbers.)

When pumping liquids under a high suction lift and cavitation or starving of the pump exists, partial recirculation through the relief valve will result in excessive noise in the valve. When it is necessary to operate under these conditions, a separate bypass valve, piped back to the storage tank, is recommended.

MAINTENANCE

MAINTENANCE AND TROUBLE SHOOTING MUST BE DONE BY AN INDIVIDUAL EXPERIENCED WITH PUMP MAINTENANCE AND THE TYPE OF SYSTEM INVOLVED.

LUBRICATION

Pump bearings should be lubricated every week to every three months, depending on the application, and the operating conditions.

Use: Standard Oil — Amolith All Weather Grease, or an equivalent grease which is compatible with the elastomers and the application.

CAUTION: Excessive greasing pressure can cause grease to be pushed between the mechanical seal faces causing seal failure.

It is recommended that you remove the grease relief fitting, and with a hand gun apply grease slowly to the grease fittings on both bearing covers until excess grease begins to come from the grease relief fitting port. Replace the grease relief fitting. It is normal for some grease to escape from the tell-tale holes under the bearing housing for a short time after lubrication.

Before starting the pump, put oil in the gear reducer using the grade oil stamped on the instruction plate attached to the gear case. Each reducer is provided with an oil pipe plug. Remove this plug and fill with oil. Couplings with rubber inserts do not require lubrication. Other couplings are pre-lubricated at the factory, but require frequent lubrication to prevent excessive wear.

PUMP DISASSEMBLY

Before work is started on the pump, be sure the pressure is relieved, and the liquid is drained.

Remove the bearing cover capscrews and slide the bearing cover from the shaft. On the X(S) 2" and 2½" pumps, the dirt shield will come off with the bearing cover. The grease seal, located in the bearing cover cavity, will also slide off with the bearing cover.

The X(S) 2½", and 3" pumps are standardly equipped with a lockwasher and locknut installed outside the bearing on each end of the shaft. To remove the bearing locknut, bend up the engaged lockwasher tang and rotate the nut counterclockwise.

The X(S) 4" pump is equipped with bearing lock collars. To release the lock collar, remove the jam nuts and loosen the two (2) set screws. The collar can then be slid from the shaft.

Before removing the head assembly, check for burrs or roughness on the shaft that could damage the mechanical seal O-rings. The head assembly, consisting of the head, head O-ring, bearing, and mechanical seal, can now be removed from the cylinder. To do so, remove the head capscrews and carefully pry the head away from the cylinder with a screw driver. The bearing and seal are slip fit on the shaft and will slide off readily if the shaft is clean and smooth.

Next, remove the bearing from the head. After removing the bearing, the seal may be pressed or pried out with a lever, as shown in Figure 3.

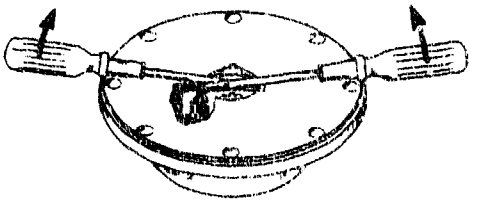


Fig. 3

NOTE: Tip of bar(s) to be inserted immediately between head and seal. If placed elsewhere, seal damage is likely (Fig. 3A).

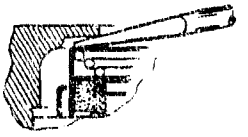


Fig. 3A — Removal of Seal

REPLACING VANES ONLY

Vanes can usually be replaced by removing only one head, and sliding them in or out of the rotor end. To prevent push rods from dropping down, a vane should only be removed when it is seated in its slot in the rotor (at the 12 o'clock position). Turn the shaft by hand until a vane comes to the 12 o'clock position.

[illegible] time this procedure until all new vanes are in place. Be sure to install the new vanes with the rounded or wearing edge outward to contact the surface of the cylinder, and with the relief grooves facing in the direction of rotation. (see Figure 4).

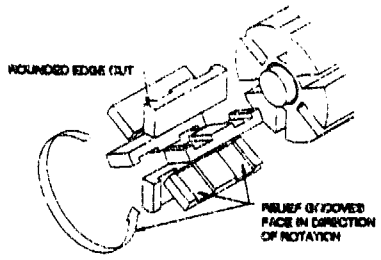


Fig. 4 — Vane Installation

PUMP ASSEMBLY

Before reassembling the pump, clean each part thoroughly. Wash out the seal and bearing recesses in the heads.

MECHANICAL SEAL

If the mechanical seal has been leaking, it is recommended that a complete new seal assembly be installed.

Wipe the inner and outer O-rings of the seal as clean as possible. Apply a small amount of oil to the O-rings to aid in installation. Place the seal in the recess in the head with the steel stamped parts pointing inward. It can be forced in place by hand pressure. The pin on the stationary seat should be to either side of the lug inside the seal recess.

BEARING

Install the bearing into the bearing bore in the head with the grease shield towards the inside, such that the balls are visible after installation.

HEAD O-RING

The head O-ring should be replaced if it is swollen, nicked or cut. The O-ring is nominally smaller in diameter than the groove. To install, lay the ring flat on the head and start in on one side of the groove. Slide thumbs over the ring in opposite directions while stretching it ahead with the fingers, as shown in Figure 5.

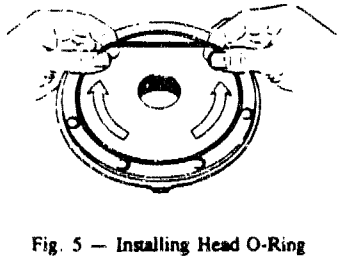


Fig. 5 — Installing Head O-Ring

ROTOR AND SHAFT

Before installing the rotor and shaft, make sure the shaft is free of burrs which might cut or nick the mechanical seal O-ring. It will be necessary to install the bottom vanes and push rods before replacing the rotor and shaft. The vanes must be held in place as the rotor and shaft is inserted into the cylinder.

VANES

When installing the vanes, be sure the rounded or wearing edge is outward to contact the surface of the cylinder, with the relief grooves facing in the direction of rotation (refer back to Figure 3). To install the remaining vanes, turn the shaft by hand until an empty slot comes to the 12 o'clock position, insert a vane, and rotate to the next empty slot.

HEAD ASSEMBLY

Before installing the head assembly, make sure the shaft is free of burrs which might cut or nick the mechanical seal O-rings. A small amount of oil applied to the shaft will help slide the parts in place.

Place the head assembly on the shaft with the tell-tale hole in the bearing housing pointing downward. Slide the head against the cylinder.

Install and partially tighten four (4) head capscrews, 90° apart, on each end of the pump. The capscrews should be tightened enough to squeeze the head O-ring and allow metal to metal contact between the head and cylinder. Rotate the shaft by hand to test for binding or tight spots. If the rotor does not turn freely, lightly tap the rim of the heads with a lead hammer to better center the rotor. Recheck for binding. When the correct position is found, install the remaining head capscrews and fully tighten all capscrews.

LOCKNUT & LOCKWASHER — X(3) 2½" & 3" PUMPS

The pump must be free turning with all head capscrews tight before making an adjustment on the locknuts. The purpose of locknut adjustment is to center and maintain the pump rotor between the heads.

It is important that the bearing locknuts and lockwashers be installed properly. Overtightening locknuts will cause bearing failure and/or a broken lockwasher inner tang "A" (see Fig. 6). Loose locknuts will allow the rotor to shift against the heads, causing wear.

PUMP TROUBLES AND THEIR CURES

LEAKAGE

New mechanical seals may leak slightly until the mating surfaces have had an opportunity to seat properly. If the leakage becomes excessive or continuous, the mechanical seal should be replaced. Leakage will appear at the tell-tale hole under the bearing housing.

If there is leakage between the pump head and casing, the head should be removed and checked for burrs or dirt. Also, check the face of the casing to make sure it is clean and smooth. Gently file any burrs or rough spots. Head O-rings should be inspected for cuts or nicks, and replaced if found to be damaged.

ESCAPING GREASE

Grease will appear at the grease relief fitting on the bearing cover after normal greasing of the pump. The amount should not become excessive nor continue for an extended period of time. If it continues, remove the grease relief fitting and examine for damage. Replace if necessary.

If excessive grease escapes around the pump shaft, remove the bearing cover and inspect the grease seal for damage. Reinstall the bearing cover with the grease seal centered on the shaft.

NOISE

If a pump has been drained and flooded with air there may be some noise in the relief valve when the pump is next started. It is usually of short duration, and will not damage the pump.

Excessive vacuum on the pump due to restricted suction can cause cavitation noise. There are several possible causes of excessive vacuum:

- Inlet piping too small.
- Strainer plugged or dirty.
- Undersized or restricted fittings, such as globe valves, or partially closed valves.
- Suction lift too great.
- Pump speed too high for the viscosity of the liquid being pumped.

If the pump is run for extended periods with a closed discharge, causing the liquid to circulate through the relief valve, vaporization will occur and create excessive noise.

Exceeding the recommended maximum speed can also cause noise in the pump.

If all of the above have been checked, and the pump is still noisy and not delivering the rated capacity, the vanes should be examined for possible damage.

DAMAGED VANES

Vanes can be damaged by the following:

- Pumping liquids which chemically attack the vane material.
- Foreign objects entering the pump.
- Pumping liquids of too high viscosity.
- Excessive heat.
- Incorrect vane installation (see "Replacing Vanes").
- Cavitation.
- Overspeeding.

It is advisable to replace the vanes if they indicate push rod penetration, are worn unevenly, or have raised projections on the wearing edge.

LOW DELIVERY RATE

A low delivery rate may be caused by:

- Restriction in the suction line.
- Resistance in the discharge line.
- Air leaks in the suction line.
- Damaged or worn pump parts.
- Pump speed too low or too high.

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PUMP PERFORMANCE DATA

	PUMP MODEL*																			
	G(X)(S)2 X(S)2				G(X)(S)2½ X(S)2½				G(X)(S)3 X(S)3				X(S)3½				G(X)(S)4 X(S)4			
RATED PUMP SPEED (RPM)	640	520	420	350	640	520	420	350	640	520	420	350	640	520	420	350	500	400	300	230
U.S. GPM	72	58	46	38	129	104	84	69	263	211	170	140	336	272	218	181	505	405	280	220
LPM	273	220	174	144	488	394	318	261	995	799	644	530	1268	1028	824	686	1912	1533	1060	833
HP	3.0	2.5	1.9	1.7	6.0	4.0	3.3	2.8	9.5	7.8	8.0	8.0	12.5	10.1	7.8	7.5	17.5	18.0	11.0	8.0

*Approximate capacities and horsepower (HP) are based upon a 100 SSU (22Cs) liquid at 50 psi (345 kPa) differential pressure. Refer to performance curves for capacities and horsepower at other pressures and viscosities.

MAXIMUM OPERATING LIMITS

PUMP MODEL	DIFFERENTIAL PRESSURE		VISCOSITY**		NOMINAL FLOWRATE		TEMPERATURE		WORKING PRESSURE		PUMP SPEED
	PSI	kPa	SSU	Cs	GPM	LPM	°F	°C	PSI	kPa	RPM
G(X)(S)2 X(S)2	125	862	50,000	10,500	90	340	300	148	175	1207	780
G(X)(S)2½ X(S)2½	125	862	50,000	10,500	162	612	300	148	175	1207	780
G(X)(S)3 X(S)3	125	862	50,000	10,500	270	1021	300	148	175	1207	640
X(S)3½	150	1034	40,000	8,500	336	1281	300	148	350	2413	640
G(X)(S)4 X(S)4	125	862	50,000	10,500	520	1966	300	148	175	1207	500

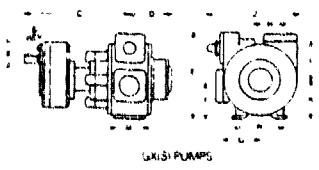
**G(X)(S) models are limited to 10,000 SSU (2200 Cs) maximum viscosity.

Note: Optional materials of construction may be required to meet specific application requirements – Refer to Blackmer Material Specification Sheets. For operating conditions that exceed those listed – Consult factory.

COMPANION FLANGES

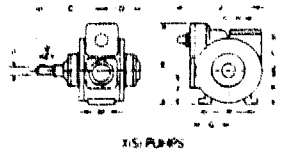
PUMP MODEL	STANDARD	OPTIONAL
G(X)(S)2 X(S)2	2" NPT	2" Blackmer Weld, 2" Flanged Elbow, 1½" NPT
G(X)(S)2½ X(S)2½	2½" NPT	2½" Blackmer Weld, 2½" Flanged Elbow, 2" NPT
G(X)(S)3 X(S)3	3" NPT	3" Blackmer Weld, 3" Flanged Elbow
X(S)3½	Inlet: 4" Blackmer Weld Discharge: 3" Blackmer Weld	3" NPT, Both 4" or 3" Blackmer Weld
G(X)(S)4 X(S)4	4" NPT	4" Blackmer Weld

DIMENSIONS -- Inches (mm)



G(X)(S) PUMPS

PUMP MODEL	A	B	C	D	E	F	G	H	J	K	L	M	N	APPROXIMATE W.T. WITH STD. FLANGES
G(X)(S)2	¾ (19)	⅜ (9)	11¹⁵⁄₁₆ (294)	5⅛ (137)	8¹¹⁄₁₆ (221)	3½ (89)	4 (102)	1½ (38)	9⅞ (251)	4 (102)	4⅛ (105)	1⅝ (41)	5 (127)	110 lb (50 kg)
G(X)(S)2½	¾ (19)	⅜ (9)	12⅜ (314)	6 (152)	9⅝ (244)	3⅝ (95)	4⅜ (110)	1¾ (44)	10¹¹⁄₁₆ (271)	4 (102)	5⅛ (130)	3 (76)	5½ (140)	130 lb (59 kg)
G(X)(S)3	1 (25)	¾ (9)	14⅛ (359)	6½ (165)	12⅜ (310)	4⅝ (117)	5 (127)	2½ (64)	13⅜ (340)	5¼ (127)	5¼ (133)	2½ (64)	6 (152)	230 lb (104 kg)
G(X)(S)4	1¾ (23)	¾ (9)	16⅝ (473)	8½ (209)	15⅛ (384)	5 (127)	7⅜ (187)	2½ (64)	16⅞ (429)	6⅝ (162)	8 (203)	4½ (114)	7 (203)	430 lb (195 kg)



X(S) PUMPS

PUMP MODEL	A	B	C	D	E	F	G	H	J	K	L	M	N	APPROXIMATE DRY WEIGHT WITH STD. FLANGES
X(S)2	1⅛ (29)	¾ (9)	8 (203)	5⅛ (130)	8¹¹⁄₁₆ (221)	3½ (89)	4 (102)	1½ (38)	10 (254)	4 (102)	4⅛ (105)	1⅝ (41)	5 (127)	85 lb (39 kg)
X(S)2½	1⅛ (29)	¾ (9)	9⅝ (232)	6 (152)	9⅝ (244)	3⅝ (95)	4⅜ (110)	1¾ (44)	10⅝ (273)	4 (102)	5⅛ (130)	3 (76)	5½ (140)	97 lb (44 kg)
X(S)3	1⅜ (29)	¾ (9)	9⅝ (244)	6½ (165)	12⅜ (310)	4⅝ (117)	5 (127)	2½ (64)	13⅜ (340)	5¼ (127)	5¼ (133)	2½ (64)	6 (152)	145 lb (65 kg)
X(S)3½	1¾ (37)	⅝ (9)	9⅝ (244)	6¹¹⁄₁₆ (173)	13⅜ (340)	4⅞ (124)	5⅝ (143)	2⅝ (67)	13⅛ (387)	5⅛ (130)	6¼ (159)	2½ (64)	6¼ (273)	165 lb (75 kg)
X(S)4	1½ (38)	⅜ (10)	11 (280)	8⅛ (206)	15⅛ (384)	5 (127)	7⅜ (187)	2½ (64)	16⅞ (430)	6⅝ (168)	8 (203)	4½ (114)	7 (203)	273 lb (124 kg)

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PUMP PERFORMANCE DATA

	PUMP MODEL*																			
	GX(S)2 X(S)2				GX(S)2H X(S)2H				GX(S)3 X(S)3				X(S)3H				GX(S)4 X(S)4			
RATED PUMP SPEED (RPM)	640	520	420	350	640	520	420	350	640	520	420	350	640	520	420	350	500	400	300	230
U.S. GPM	72	56	43	28	135	104	84	69	283	217	170	140	336	272	218	184	908	668	380	320
LPM	273	220	174	144	488	394	318	261	896	799	644	530	1268	1028	824	696	1912	1533	1080	833
HP	3.0	2.5	1.8	1.7	5.0	4.0	3.3	2.8	8.5	7.8	6.0	5.0	12.5	10.1	7.8	7.8	17.5	15.0	11.0	9.0

*Approximate capacities and horsepower (HP) are based upon a 100 SSU (22Cs) liquid at 50 psi (345 kPa) differential pressure. Refer to performance curves for capacities and horsepower at other pressures and viscosities.

MAXIMUM OPERATING LIMITS

PUMP MODEL	DIFFERENTIAL PRESSURE		VISCOSITY**		NORMAL PUMP SPEED		TEMPERATURE		WORKING PRESSURE		PUMP SPEED
	PSI	kPa	SSU	Cs	RPM	LPM	°F	°C	PSI	kPa	RPM
GX(S)2 X(S)2	125	862	50,000	10,830	80	340	300	148	75	1207	760
GX(S)2H X(S)2H	125	862	50,000	10,830	162	612	300	148	175	1207	760
GX(S)3 X(S)3	125	862	50,000	10,500	270	1021	300	148	175	1207	640
X(S)3H	150	1034	49,630	9,510	336	1361	300	148	350	2413	640
GX(S)4 X(S)4	125	862	50,000	10,500	320	1363	300	148	175	1207	500

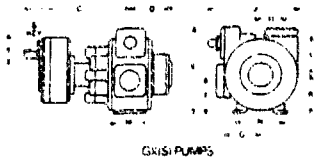
**GX(S) models are rated to 10,000 SSU (2200 Cs) maximum viscosity.

Note: Optional materials of construction may be required to meet specific application requirements – Refer to Blackmer Material Specification Sheets. For operating conditions that exceed those listed – Consult factory.

COMPANION FLANGES

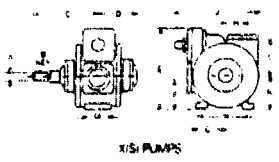
PUMP MODEL	STANDARD	OPTIONAL
GX(S)2 X(S)2	2" NPT	2" Blackmer Weld, 2" Flanged Elbow, 1½" NPT
GX(S)2H X(S)2H	2½" NPT	2½" Blackmer Weld, 2½" Flanged Elbow, 2" NPT
GX(S)3 X(S)3	3" NPT	3" Blackmer Weld, 3" Flanged Elbow
X(S)3H	Inlet: 4" Blackmer Weld Discharge: 3" Blackmer Weld	3" NPT, Both 4" or 3" Blackmer Weld
GX(S)4 X(S)4	4" NPT	4" Blackmer Weld

DIMENSIONS — Inches (mm)



GX(S) PUMPS

PUMP MODEL	A	B	C	D	E	F	G	H	J	K	L	M	N	APPROXIMATE WT. WITH STD. FLANGES
GX(S)2	¾ (19)	3/16 (5)	11 13/16 (294)	5 5/16 (137)	8 11/16 (221)	3½ (89)	4 (102)	1½ (38)	9¾ (251)	4 (102)	4½ (105)	1⅝ (41)	5 (127)	110 lb (50 kg)
GX(S)2H	¾ (19)	3/16 (5)	12 5/16 (313)	6 (152)	9⅜ (240)	3¾ (95)	4 5/16 (110)	1¾ (44)	10 11/16 (271)	4 (102)	5 1/16 (129)	3 (76)	6½ (140)	130 lb (59 kg)
GX(S)3	1 (25)	⅜ (10)	14 1/16 (358)	6½ (165)	12 7/16 (315)	4⅝ (117)	5 (127)	2½ (64)	13½ (340)	5⅝ (137)	5¼ (133)	2½ (64)	6 (152)	230 lb (104 kg)
GX(S)4	1⅛ (29)	⅜ (10)	18 11/16 (475)	8 (203)	15 (381)	5 (127)	7⅝ (187)	2½ (64)	16⅜ (429)	6⅜ (162)	8 (203)	4½ (114)	8 (203)	430 lb (195 kg)



X(S) PUMPS

PUMP MODEL	A	B	C	D	E	F	G	H	J	K	L	M	N	APPROXIMATE WT. WITH STD. FLANGES
X(S)2	1⅛ (29)	⅜ (10)	8 (203)	6½ (165)	8 11/16 (221)	3½ (89)	4 (102)	1½ (38)	10 (254)	4 (102)	4½ (105)	1⅝ (41)	5 (127)	95 lb (50 kg)
X(S)2H	1⅛ (29)	⅜ (10)	9 (229)	6 (152)	9⅜ (240)	3¾ (95)	4 5/16 (110)	1¾ (44)	10½ (273)	4 (102)	5 1/16 (129)	3 (76)	6½ (140)	97 lb (44 kg)
X(S)3	1⅛ (29)	⅜ (10)	9⅝ (244)	6½ (165)	12 7/16 (310)	4⅝ (117)	5 (127)	2½ (64)	13½ (340)	5⅝ (137)	5¼ (133)	2½ (64)	6 (152)	140 lb (68 kg)
X(S)3H	1⅛ (32)	3/16 (5)	9⅝ (244)	6 15/16 (176)	13⅜ (340)	4⅝ (124)	5½ (140)	2½ (67)	15¼ (387)	5⅝ (137)	6¼ (159)	2½ (89)	6¼ (159)	165 lb (74 kg)
X(S)4	1½ (38)	¼ (10)	11 (280)	8⅛ (206)	15⅛ (384)	5 (127)	7⅝ (187)	2½ (64)	18 7/16 (430)	6⅜ (162)	8 (203)	4½ (114)	8 (203)	275 lb (124 kg)

blackmer pump

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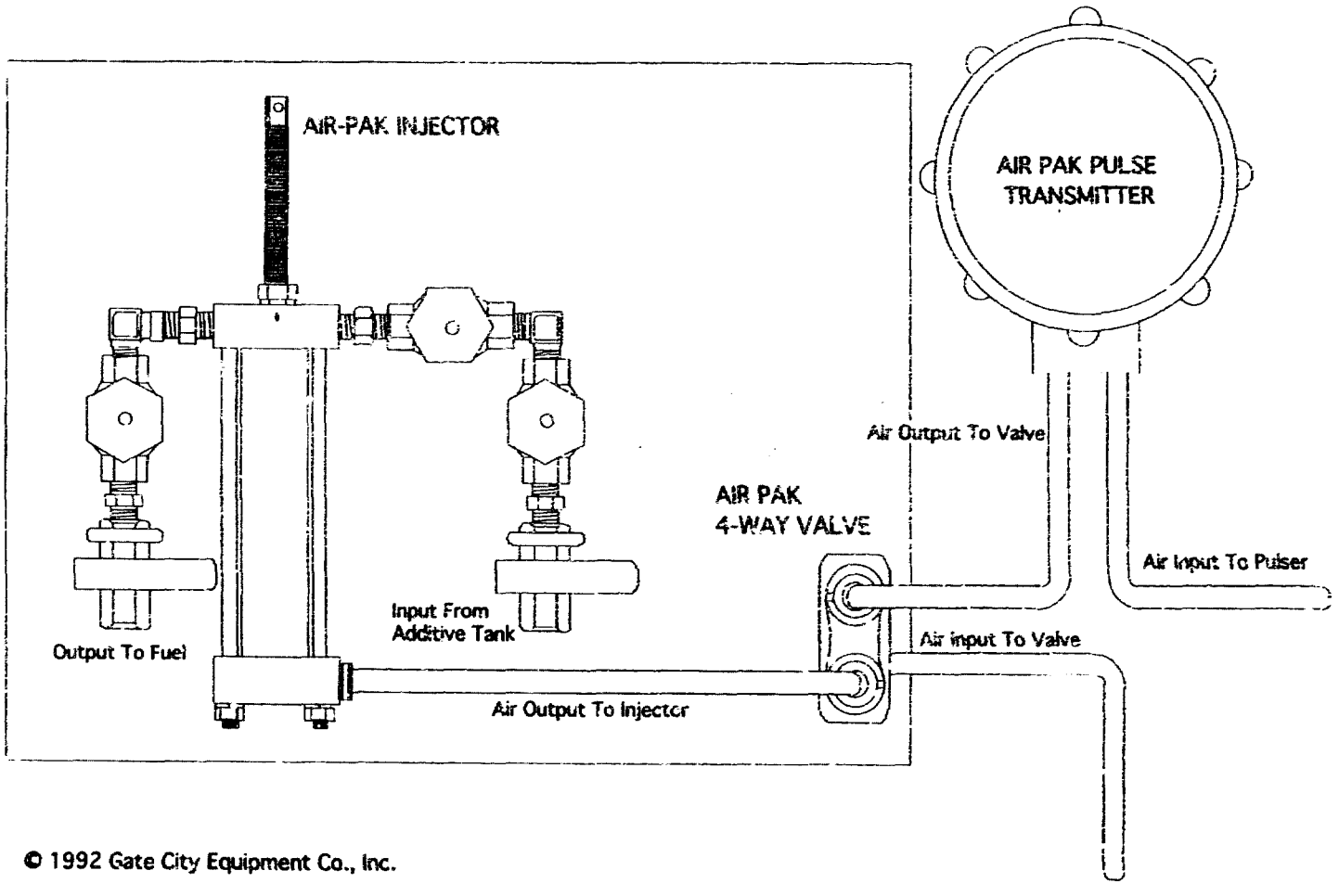
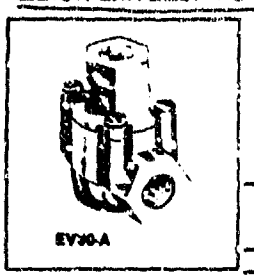
ADDITIVE INJECTION SYSTEM

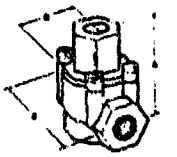
PNEUMATICALLY PULSED AIR-PAK INJECTOR



Circuitry Valves

Quick Exhaust Valves


EV30-A

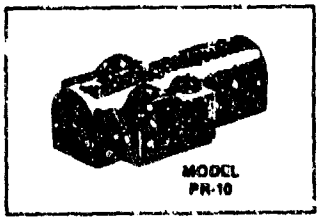


- Eliminates the need for large diameter piping or large selector valves.
- Provides quick dumping of exhaust air at the cylinder.

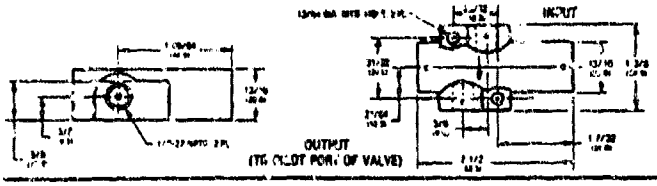
Ordering Information: Select model number for port size desired.

MODEL NO.	INLET PORT	CYL PORT	EXH PORT	PRESSURE RANGE PSI (bar)	DIMENSIONS A	B	C
EV 125	1/8"	1/8"	1/4"	2 to 125 (.37 to 8.6)	1 7/16 (36.5)	1 23/32 (43.7)	1 1/2 (38.1)
EV 250	1/4"	1/4"	3/8"	1 to 125 (.07 to 8.6)	2 1/8 (54.0)	2 7/32 (56.4)	2 1/16 (52.4)
EV 375	3/8"	3/8"	3/8"	1 to 125 (.07 to 8.6)	2 1/8 (54.0)	2 7/32 (56.4)	2 1/16 (52.4)
EV 30-A	1/2"	1/2"	3/4"	5 to 125 (.35 to 8.6)	3 1/8 (79.4)	3 1/2 (88.9)	4 1/32 (102.4)
EV 60-A	3/4"	3/4"	3/4"	5 to 125 (.35 to 8.6)	3 1/8 (79.4)	3 1/2 (88.9)	4 1/32 (102.4)

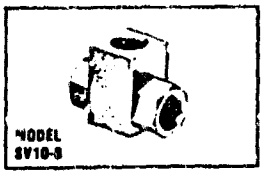
Model PR1O Single Pulse Relay Valve

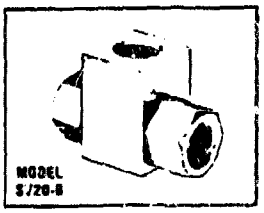

MODEL PR-10

- Converts a continuous supply of inlet air into a momentary pressure pulse.
- Has a minimum pulse pressure of 35 PSIG (2.4 bar) and an operating range of 35 to 150 PSIG (2.4 to 10.3 bar).
- Ideal for applications where an input signal remains pressurized, but its output must go "off" after performing its task.
- The PR10 converts this output into a pulse with sufficient duration and flow to shift a double pilot operated power valve. The power valve can then be returned to its original position by an opposing signal.
- For best results, the PR 10 should be as close to pilot port of valve as possible.



SUPPLY PSIG PRESSURE (bar)	PULSE DURATION ms	RESET TIME ms
50 (3.5)	125	160
75 (5.2)	110	170
100 (6.9)	105	180
125 (8.6)	100	190


MODEL SV10-B

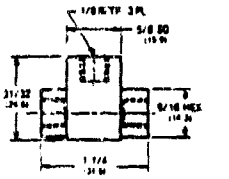

MODEL SV20-B

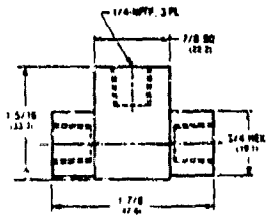
Model SV1O-B and Model SV2O-B Shuttle Valves

- Operates as a 3-way valve with two inlet ports and one outlet port.
- Check ball moves away from the inlet port with the greatest pressure and against the port having the least pressure (a minimum pressure differential of 10 PSIG (.7 bar) is necessary to effect shuttle change).
- Has Buna-N check ball seats.
- 200 PSIG (13.8 bar) maximum.

Ordering Information: Order model no. associated with port size required.

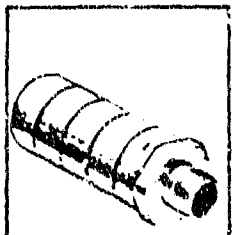
MODEL NO.	INLET PORTS (2)	OUTLET PORT (1)
SV10-B	1/8"	1/8"
SV20-B	1/4"	1/4"





WARNING: Inappropriate or improper use, application, installation, service or maintenance of ARO valves may create a hazardous or dangerous condition or situation. Please carefully read the warning and cautions on inside back cover page of this catalog.

Valve Accessories



MODEL 20308-X

Model 20308-X Exhaust Silencer

- Used to reduce the exhaust noise of air powered motors and valves.
- Recommended for all high C.F.M. applications. Has high flow capacity and low back pressure with no build up.
- No service required, no replacing of cartridges, compact, corrosion resistant, all metal construction housing.

Ordering Information: Select model for thread size desired.

MODEL NO.	PORT SIZE	DIA. IN. (mm)	LENGTH IN. (mm)	WEIGHT OZ. (g)
20308-1	1/8"	13/16 (20.6)	2-1/8 (54.0)	1.1 (31.2)
20308-2	1/4"	13/16 (20.6)	2-1/4 (57.2)	1.1 (31.2)
20308-3	3/8"	1-1/4 (31.8)	3-7/16 (87.3)	3.3 (93.6)
20308-4	1/2"	1-1/4 (31.8)	3-9/16 (90.5)	3.3 (93.6)
20308-6	3/4"	2 (50.8)	5-3/8 (136.5)	2.4 (68.0)
20308-8	1"	2 (50.8)	5-1/2 (139.7)	2.4 (68.0)

MODEL 20311-1

Model 20311-X Sintered Bronze Breather Vents

- For use on single acting cylinders and valves to prevent dirt and foreign particles from entering ports open to atmosphere.
- 40 micron filtration.
- For vacuum relief or pressure equalization on gear boxes, reservoirs, and air tanks.

Ordering Information: Select model for thread size desired.

MODEL NO.	PORT SIZE	OVERALL LENGTH IN. (mm)	HEX
116464	#10—32	23/32 (18.2)	5/16
20311-1	1/8"	7/16 (11.1)	7/16
20311-2	1/4"	5/8 (15.9)	9/16
20311-3	3/8"	3/4 (19.1)	11/16
20311-4	1/2"	7/8 (22.2)	7/8
20311-6	3/4"	1 (25.4)	1-1/16
20311-8	1"	1-5/16 (33.3)	1-5/16

MODEL 20312-X

Model 20312-X Exhaust Muffler

- Sintered bronze air muffler and exhaust diffuser for use on exhaust ports of valves.
- Sound deadening qualities with low pressure drop.
- 40 micron nominal filtration.

Ordering Information: Select model for thread size desired.

MODEL NO.	PORT SIZE	OVERALL LENGTH IN. (mm)	HEX
20312-1	1/8"	1 1/8 (28.6)	7/16
20312-2	1/4"	1 3/8 (34.9)	9/16
20312-3	3/8"	1 1/2 (38.1)	11/16
20312-4	1/2"	1 7/8 (47.6)	7/8
20312-6	3/4"	2 1/4 (57.2)	1 1/16
20312-8	1"	2 7/8 (73.0)	1 5/16

MODEL 20313-X

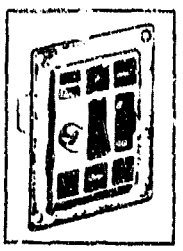
Model 20313-X Exhaust Speed Controls

- Controls the metering of air flow on exhaust ports of air valves. The speed of operating cylinder may be increased or decreased with adjusting screw. Adjusted position may be locked in place by lock nut.
- Exhaust sleeve is sintered bronze held in position by 2 brass parts.

Ordering Information: Select model for thread size desired.

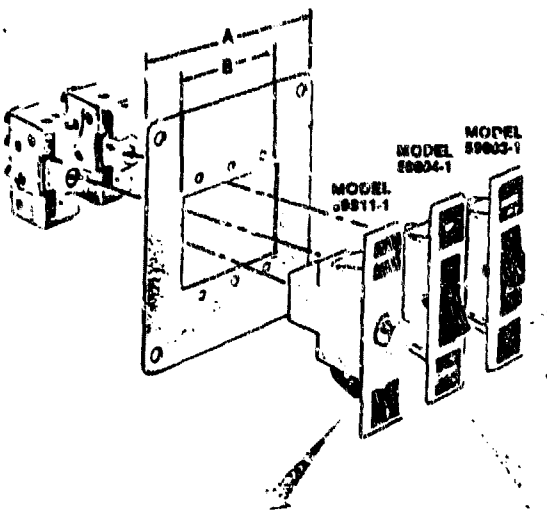
MODEL NO.	PORT SIZE	OVERALL LENGTH (CLOSED) IN. (mm)	OVERALL LENGTH (OPEN) IN. (mm)
20313-1	1/8"	1 3/8 (34.9)	2 (50.8)
20313-2	1/4"	1 9/16 (39.7)	2 3/16 (55.6)
20313-3	3/8"	1 7/8 (47.6)	2 13/16 (71.4)
20313-4	1/2"	2 1/4 (57.2)	3 5/16 (84.1)
20313-6	3/4"	2 3/4 (69.9)	3 13/16 (96.8)
20313-8	1"	3 1/4 (82.6)	4 5/8 (117.5)

Panel Mounted Miniature Control Valves and Indicators



- Uses basic 200 series 3-way valve.
- Each valve can be plumbed to perform as normally passing, normally non-passing, selector, or any two-way function.
- Valves available with push button or rocker type selectors.
- Indicators can be viewed at full 180° viewing angle.
- Valves and indicators have positive snap-in design for quick and easy installation.
- Can be stack mounted in multiples using panel cut-out method or ARO's 59796-X mounting plates.
- Self-adhesive legend sheets available.

Ordering Information: Both valves and indicators come complete. Order mounting plates and legend sheets separately.



59796-X Mounting Plates

Model	"A" Dim. Inches (mm)	"B" Dim. Inches (mm)	Number of Controls
59796-1	9/16" (14 mm)	1 11/16" (43 mm)	1
59796-2	1 1/4" (32 mm)	2 3/8" (60 mm)	2
59796-3	1 15/16" (49 mm)	3 1/16" (78 mm)	3
59796-4	2 5/8" (67 mm)	3 3/4" (95 mm)	4
59796-5	3 5/16" (84 mm)	4 7/16" (113 mm)	5
59796-6	4" (102 mm)	5 1/8" (130 mm)	6

59724 Legend Sheets

Model 59724-X Legend Sheets are self-adhesive identification legends that fit the 9/16" (14 mm) recessed square on the valves and indicators. Each sheet contains six blank and 37 different (2 each) legends. The dash number represents background color (-1 white, -2 black, -3 green, -4 red).

Panel Mount Indicators

Pressure/Temperature .... Same as 200 Series Valves see page 4

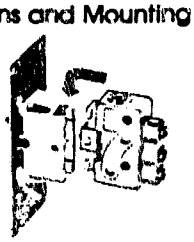
Model	Indicator Color	Port
59811-1	Red	1/8" NPT(F)
59811-3	Green	

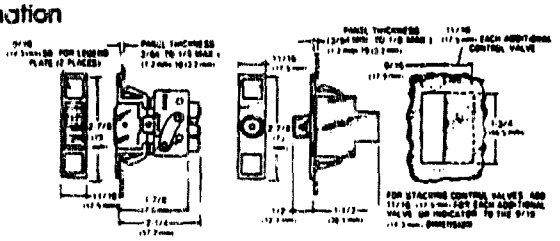
3-Way Control Valve Assembly

Pressure/Temperature/Flow .. Same as 200 Series Valves see page 4

Models/Instant Tube Fittings	Models/1/8" NPT(F) Ports	Actuation Type	Port Designation
59803-1	59803	Pushbutton (Momentary)	1-in non-passing
59804-1	59804	Rocker (Maintained)	3-in passing 2-output

Dimensions and Mounting Information



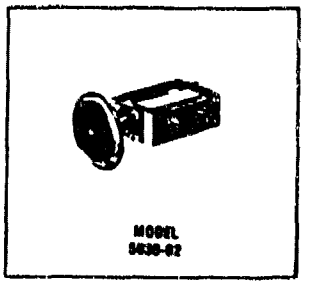


50 Series Valves

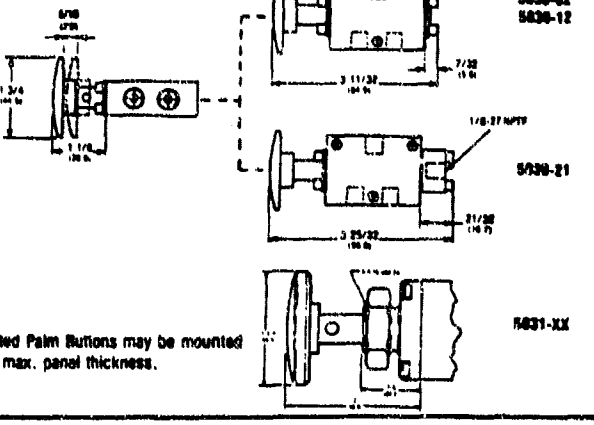
1/8" Ports

3-Way Palm Button

Function control



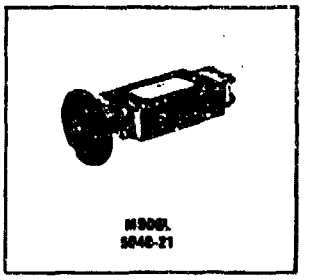
MODEL
5030-02



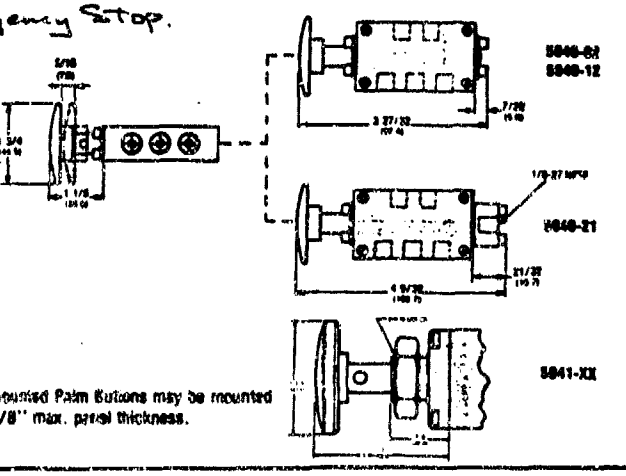
Panel Mounted Palm Buttons may be mounted up to 1/8" max. panel thickness.

4-Way Palm Button

Emergency Stop.

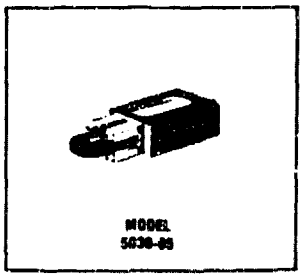


MODEL
5040-21

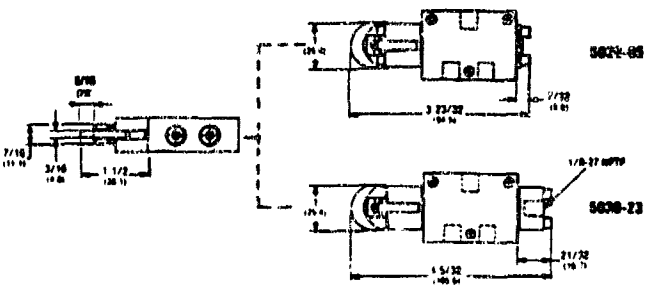


Panel Mounted Palm Buttons may be mounted up to 1/8" max. panel thickness.

3-Way Roller Cam



MODEL
5030-03



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Alpha Series Body Ported 4-Way Valves 1/8" & 1/4" Ports

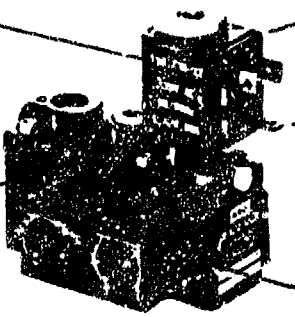
Application Information

- 5-ported, 4-way valve enables use of speed controls at valve's exhaust ports.
- Control the valves one of five ways: single solenoid, double solenoid, single pilot, double pilot and solenoid/pilot.
- Class F solenoid coils are rated for 100% duty cycle.
- A micro circuit relay connector is available and makes the valve TTL compatible.
- Two override methods provide a convenient way to set-up and trouble shoot circuits without electrical power to the solenoids.
- For information on connectors and replacement coils, see pages 53 and 54.
- Solenoid models are also available with molded leads.
- For information on the light emitting seal (L.E.S.) see page 13.

Feature / Benefit Information

Quick change coil can easily be interchanged or replaced by removing nut, sliding existing coil off and a new coil on.

Die cast aluminum alloy body with Delrin® end caps, gives strength and corrosion resistance.



Five actuator options available: single pilot, double pilot, single solenoid, double solenoid and solenoid/pilot.

Plug-in connectors cut installation time and give secure hook-ups. Each connector is its own junction box, eliminating the need to wire the solenoid to a secondary junction box.

One piece, balanced spool provides quick response and high flow. Urethane seal is bonded to aluminum spool to resist wear.

Delrin ® is a registered trademark of the Dupont Corporation.

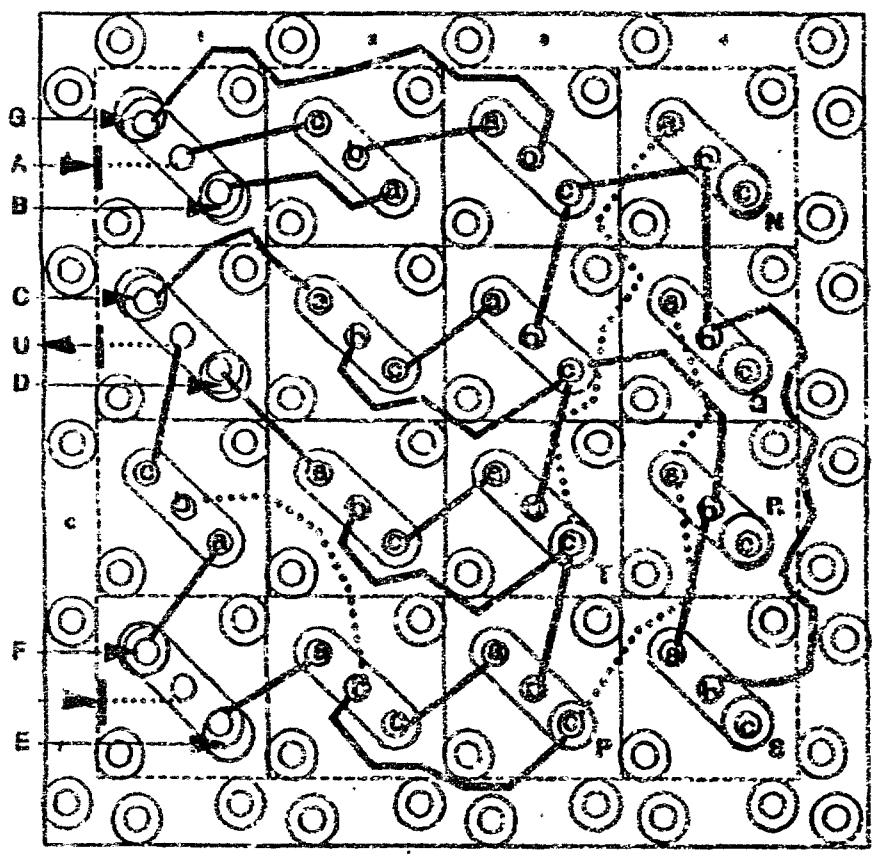
Specifications

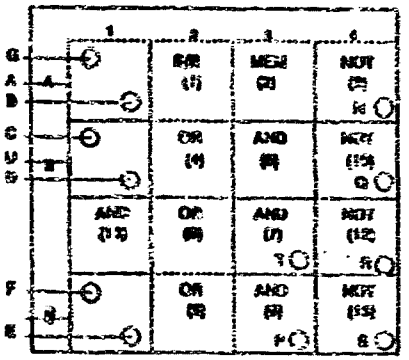
Lubrication: Valves are pre-lubed and can be operated without air line lubrication to an approximate life of 20 million cycles, depending on application. If air cylinders or other air line devices require lubrication, ensure that lubrication oils are compatible with valve seals and of sufficient viscosity to assure adequate lubrication. See Page 62 for list of suggested oils.

- Cycles per minute is rated at 600 CPM on all Alpha Valves.

TYPE ACTUATOR	TYPE RETURN	PORT SIZE	PRESSURE RANGE PSI (bar)	MIN. PILOT PRESSURE PSI (bar)	FLOW* SCFM (dm³/s)	Cv FACTOR	WEIGHT lbs. (g)	AMBIENT TEMPERATURE
Pilot	Spring	1/8"	Vacuum To 150 (10.4)	50 (3.5)**	30 (14.2)	0.9	7.1 (201)	0° to 180°F (18° to 82°C)
Pilot	Spring	1/4"		50 (3.5)**	50 (23.6)	1.5	6.7 (190)	
Pilot	Pilot	1/8"		25 (1.7)	30 (14.2)	0.9	7.1 (201)	
Pilot	Pilot	1/4"		25 (1.7)	50 (23.6)	1.5	6.7 (190)	
Solenoid	Spring	1/8"		50 (3.5)**†	30 (14.2)	0.9	10.1 (286)	
Solenoid	Spring	1/4"		50 (3.5)**†	50 (23.6)	1.5	9.7 (275)	
Solenoid	Solenoid	1/8"		25 (1.7)†	30 (14.2)	0.9	13.1 (371)	
Solenoid	Solenoid	1/4"		25 (1.7)†	50 (23.6)	1.5	12.7 (360)	

*SCFM at 80 PSI (5.5 bar) supply and 65 PSI (4.5 bar) downstream pressure.
**Use 60 PSI (4.1 bar) min. pilot pressure for 3-position valves.
†Use for low pressure and vacuum supply.





3 PCS 59019 PORT BLOCK
1 PC. 59131 S/R GATE
1 PC. 59113 MEM ELE.
3 PCS. 59010 OR ELE.
4 PCS. 59111 AND ELE.
4 PCS. 59112 NOT ELE.
2 PCS. 59230-44 BASE PLATE
1 PC. 59201-44 COVER PLATE
2 PCS. 59095-88 MODULE
1 PC. 59057 P. BOLT KIT

ARO

PNEUMATIC LOGIC CONTROL

DWG.

DRAWN 59003-585

DATE 4/8/82

AIR COMPRESSOR

THOMAS INDUSTRIES INC.

POWER AIR DIVISION
1410 ILLINOIS AVENUE, SHEBOYGAN, WISCONSIN 53082

T-30 Series

WOB-L PISTON COMPRESSOR

AIR-PAC®

Portable, Oil-Less
Heavy-Duty Air Compressors

GENERAL DESCRIPTION

Performance in tandem with portability makes the Air-Pac T-30 Series our finest, most convenient tank compressor which is perfect for the professional and serious do-it-yourselfer. This compressor includes air storage tanks, and an automatic pressure switch control.

SPECIFICATIONS

H.P. ..... 1.0 @ 1720 RPM
Voltage ..... 115 V. 60 HZ
Starting Voltage (min.) ..... 90 V
Fuse Requirements ..... 15 A
Safety Valve Setting ..... 140 PSIG (965.3 KPa)
Air Displacement ..... 4.5 CFM (127.4 LPM)
Air Delivery ..... 2.95 CFM @ 50 PSI
..... (83.54 LPM @ 345 KPa)
..... 2.65 CFM @ 80 PSI
..... (75.05 LPM @ 552 KPa)
..... 2.55 CFM @ 100 PSI
..... (72.22 LPM @ 689.5 KPa)
Amps at Working Pressure ..... 10.5 A
Automatic Control ..... Starts @ 95 PSIG
..... (655 KPa)
..... Stops @ 125 PSIG
..... (861.9 KPa)
Tank Size ..... 2 Gal. EACH (Total 4 Gal.)
..... (T-30 HP) 0.50 Gal. TOTAL
Weight ..... 82 lbs.
Cord ..... 6 ft. (1.82 M)

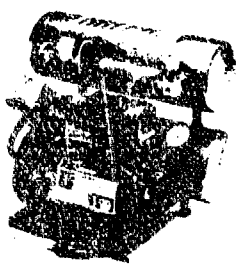
PSI = Pounds Per Square Inch
KPa = Kilopascals
CFM = Cubic Feet Per Minute
LPM = Liters Per Minute

APPLICATION

Ideal as primary or secondary air source for almost any operation. Particularly suitable for shops, garages, and factories where repetitive use demands high reliability.

T-30HP

T-30WT



T-30ST

Part No. 636934 Rev. A 7-91

GENERAL MAINTENANCE AND SERVICE

FOR SERVICE AND PARTS

For service contact the dealer from whom you purchased the compressor.

To place parts orders: Provide the model data located on the nameplate of the compressor and call our parts department 1-800-323-0620

⚠ **WARNING:** Read and understand the information in this owner's manual before operating air compressor.

1. The compressor should be located in a dry, clean, and well ventilated area.
2. Inspect before use: hose, plug, and cord for signs of damage. Do not use if a deficiency is found. Contact your nearest service center for replacement parts. Never operate a damaged unit.
3. **Do not tamper with safety valve as it has been factory set. Any adjustment with this valve could cause serious injury.**
4. This air compressor needs no lubrication. Applying oil to any part could result in polluted air delivery to the air-handling equipment.
5. Compressed air must never be aimed at anyone because it can cause serious injury. Keep children away. WEAR EYE PROTECTION.
6. All air compressors generate heat even under normal operating conditions. To avoid serious burns, never touch the air compressor during or immediately after operation.
7. When unit is not in use, wrap cord around compressor and store in dry place. Do not abuse cord.
8. Before servicing, cleaning or removal of any part, shut off power and relieve pressure.
9. This system produces 125 PSI. To avoid rupture and injury, do not operate this pump with components rated less than 125 PSI working pressure (including but not limited to spray guns, hose and hose connections without pressure regulator).

If warranty service or repairs are needed contact your nearest authorized service center. If one does not exist contact the factory. Unauthorized repairs or teardown of the unit will void factory warranty.

SET UP

Location of Air Compressor

Operate air compressor in a clean, dry and well ventilated area. The air filter must be kept clear of obstructions which could reduce air flow to the compressor. The air compressor should be located at least 12" away from walls or other obstructions that could interfere with the flow of air.

Extension Cords

To avoid voltage drop and power loss to motor, use additional hose instead of an extension cord. If an extension cord must be used, use only a 3-wire extension cord equipped with a 3-blade grounding plug and a 3-slot receptacle that will accept the plug on the compressor. Make sure the extension cord is in good shape.

MINIMUM GAUGE FOR EXTENSION CORDS				
CORD LENGTH	25 FEET	50 FEET	100 FEET	150 FEET
GAUGE	16	14	10	8

NOTE: Wire size increases as gauge number decreases.

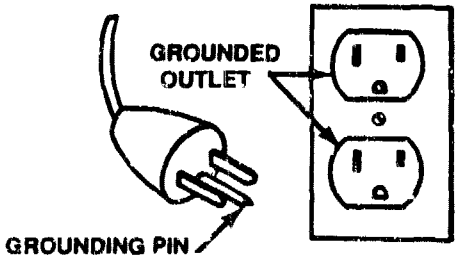
Grounding Instructions

⚠ **WARNING:** Improper grounding can result in electrical shock. In the event of a short circuit, grounding reduces the risk of shock by providing an escape wire for the electric current. The air compressor must be grounded.

The air compressor cord is equipped with a grounding wire and appropriate grounding plug. The plug must be used with an outlet that has been installed and grounded in accordance with all local codes and ordinances. The outlet must have the same configuration as the plug. Do not use an adapter.

Do not modify the plug that has been provided. If it does not fit the available outlet, the correct grounded outlet must be installed by a qualified electrician.

Inspect the plug and cord before each use. Do not use compressor if there are signs of damage.



⚠ **WARNING:** Improper installation of the grounding plug can result in electrical shock. If repair or replacement of the cord or plug is required, do not connect the grounding wire to either flat blade terminal. The wire with the green (with or without yellow stripes) insulation is the grounding wire and must be connected to the grounding pin.

Check with a qualified electrician if the grounding instructions are not completely understood, or if unsure unit is properly grounded.

OPERATION

Safety Valve
The safety valve (item 24 - tank drawings) is designed to prevent pressure in the storage tank from exceeding 140 PSIG.

⚠ **WARNING:** Do not tamper with or attempt to eliminate the safety valve.

Thermal Overload Protector
The compressor motor is equipped with a thermal overload protector. If the motor should overheat, the overload protector will shut the motor off. If this occurs, turn the on/off lever to the off position and allow motor to cool for approximately 5 minutes.

NOTE: Tank pressure must be below 95 PSIG for the compressor to start.

Restart the compressor by moving on/off lever to the on position. If compressor fails to start, check for blown fuses; the compressor may require more time to cool. If the overload protector shuts down the motor frequently, it could be due to low voltage. Common signs of low voltage are:

1. Motor does not get up to power or speed.
2. Fuses or circuit breaker activate when starting compressor.
3. Lights dim or remain dim when compressor is started.
4. Other motor operated appliances fail to operate properly.
5. Too many motor operated appliances on same circuit.

Operating Procedures

1. Make sure on/off lever is in the off position.

⚠ **WARNING:** Before using air tools or accessories, check manufacturer's maximum pressure rating. Maximum pressure rating must be above 125 PSIG.

2. Attach air hose and accessory.
3. Turn on/off lever to the on position and allow tank pressure to build.
4. When the motor stops, it has reached cutout pressure and the unit is ready for use.

NOTE: When using an accessory or air tool, pressure in the storage tank decreases. When it reaches a certain low level (cut-in pressure) the motor will automatically restart and raise the pressure in the storage tank.

5. To shut down compressor, simply move on/off lever to the off position.
6. Allow compressor to cool.
7. Drain storage tank (see Storage Tank in Maintenance Section).

MAINTENANCE

Air Filter
Inspect air filter (item 49 - compressor drawing) before each use. Clean filter with soap and water as necessary. If filter becomes clogged or damaged, replace it.

⚠ **WARNING:** Never clean air filter with a flammable liquid or solvent. Explosive vapors may accumulate in the air tank and cause an explosion, resulting in serious injury or death.

CAUTION: Do not operate air compressor without air filter.

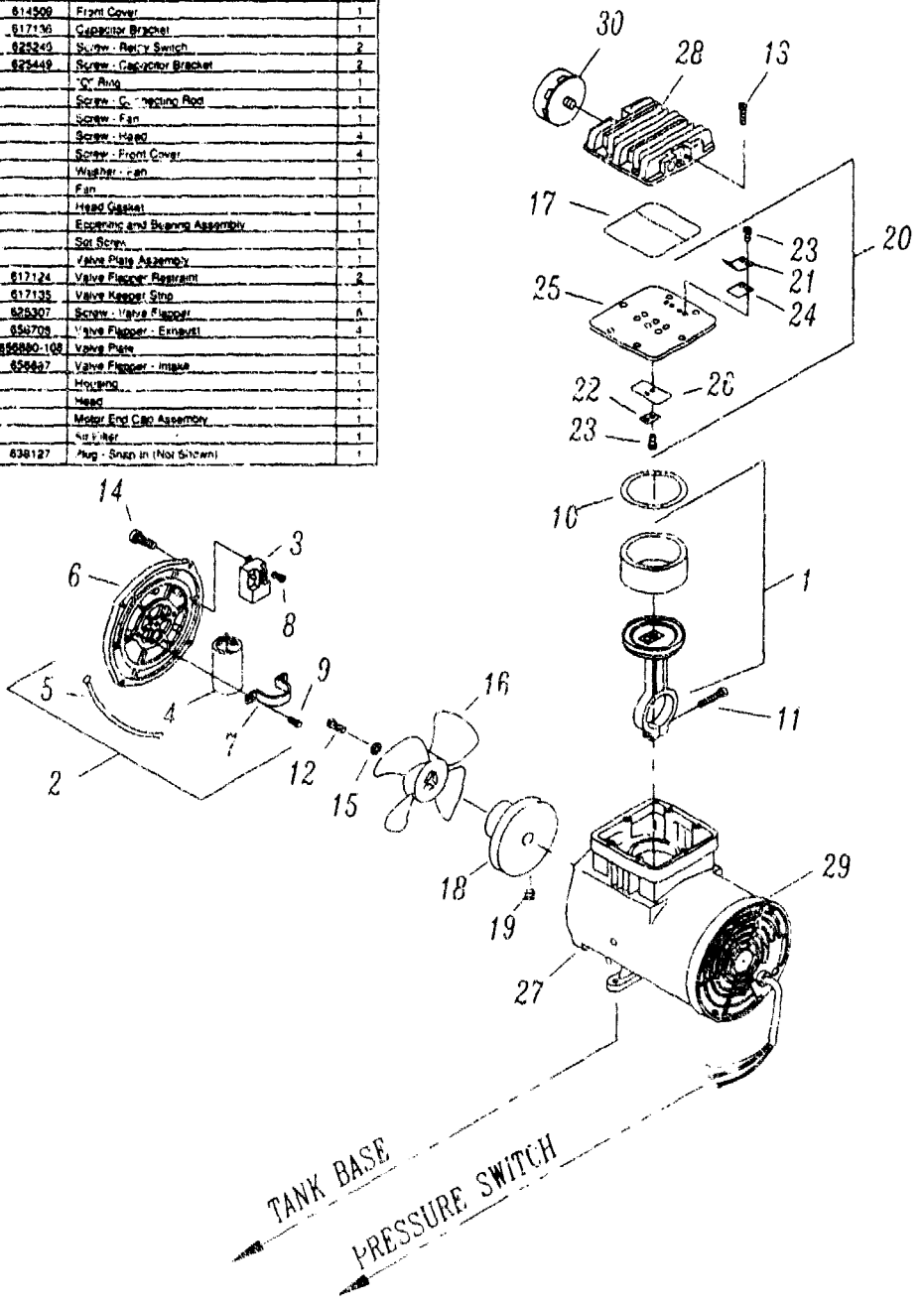
Storage Tank
Storage tank should be drained after each use or after every four hours of operation to prevent condensation build-up and corrosion inside tanks. To drain tank, slowly and carefully open drain fitting (item 8 - tank drawings), tip unit upright and allow water to drain out.

NOTE: When draining tank, watch for debris (rust particles). If there appears to be debris in water, contact your dealer for possible tank replacement. It is recommended the tank be replaced every three years.

⚠ **WARNING:** Do not weld on the air tank of this compressor. Welding on the air compressor tank can severely impair tank strength and cause an extremely hazardous condition. Welding on the tank in any manner will void the warranty. If warranty service or repairs are needed contact your nearest authorized servicing dealer. If one does not exist contact the factory. Unauthorized teardown of the unit will void the factory warranty.

DRAWING AND PARTS LIST FOR T-30 COMPRESSOR DRAWING

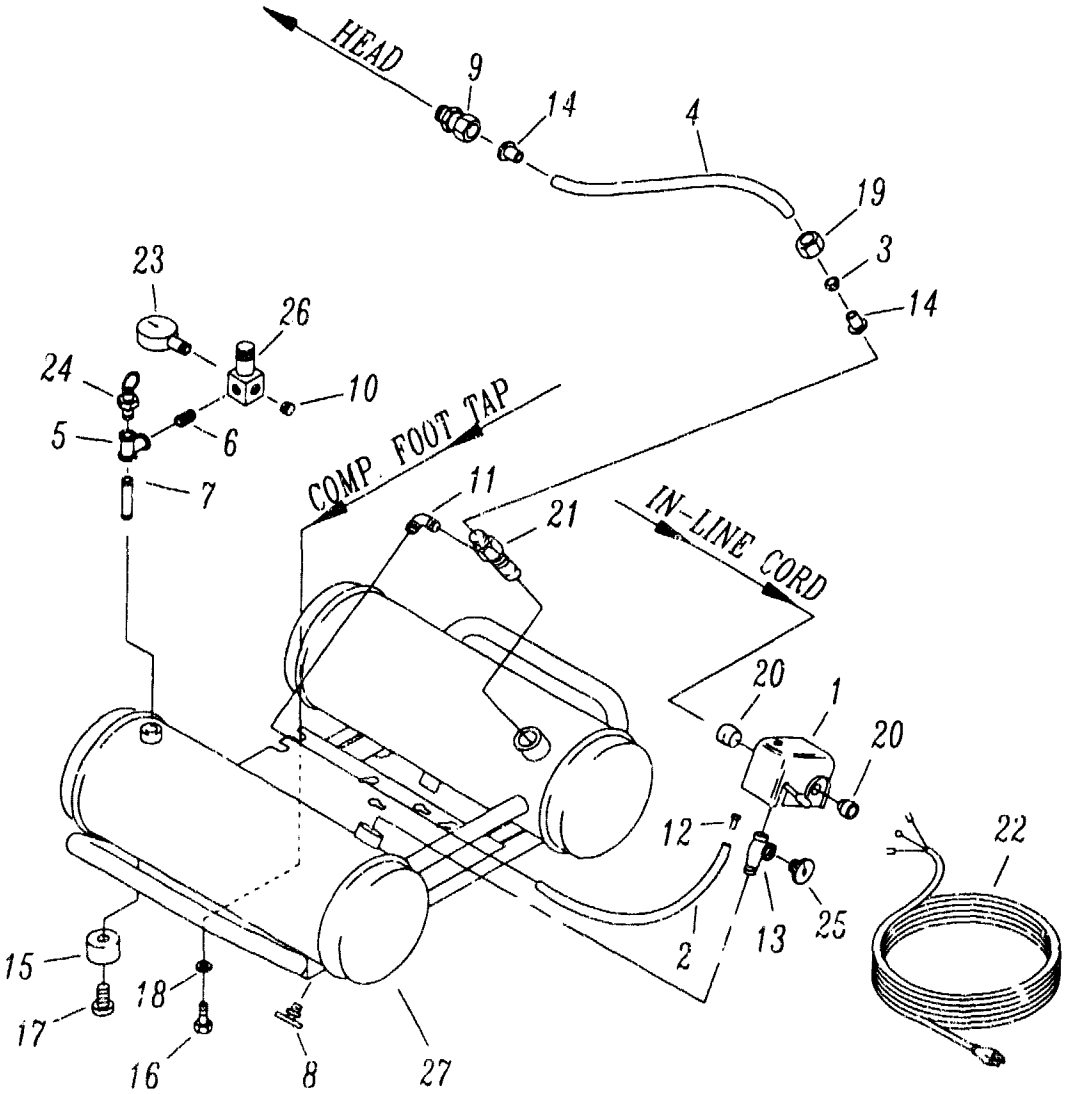
Item	Part No.	Comp. Part	Description	Qty.
1	607573		Connecting Rod Assembly	1
2	614770		Front Cover Assembly	1
3		602219	Relay Switch	1
4		603021	Capacitor	1
5		604286	Lead Wire Assembly	1
6		614509	Front Cover	1
7		617136	Capacitor Bracket	1
8		625249	Screw - Relay Switch	2
9		625449	Screw - Capacitor Bracket	2
10	623541		"O" Ring	1
11	625114		Screw - Connecting Rod	1
12	625354		Screw - Fan	1
13	625436		Screw - Head	4
14	625448		Screw - Front Cover	4
15	626563		Washer - Fan	1
16	633718		Fan	1
17	633861		Head Gasket	1
18	645774		Bearing and Bushing Assembly	1
19	625008		Set Screw	1
20	656975-108		Valve Plate Assembly	1
21		617124	Valve Flapper Restraint	2
22		617135	Valve Keeper Stop	1
23		625307	Screw - Valve Flapper	6
24		656709	Valve Flapper - Exhaust	4
25		656880-108	Valve Plate	1
26		656887	Valve Flapper - Intake	1
27	661430-300		Housing	1
28	661964-108		Head	1
29	662480-108		Motor End Cap Assembly	1
30	641111		Air Filter	1
31		638127	Plug - Snap in (Not Shown)	1



DRAWING AND PARTS LIST FOR T-30 WIDE TANK DRAWING

Item	Part No.	Description	Qty.
1	802936	Pressure Switch	1
2	815716	Unloader Tube	1
3	815750	Sleeve - Self Aligning	1
4	815752	Exhaust Tube 11"	1
5	824015	Pipe Tee	1
6	824016	Close Nipple	1
7	824044	Pipe Nipple	1
8	824200	Drain Fitting	2
9	824318	Connector	1
10	824327	Pipe Plug - Regulator	1
11	824361	Elbow	1
12	824510	Tubing Insert	1
13	824513	Street Tee	1
14	824547	Tubing Insert	2

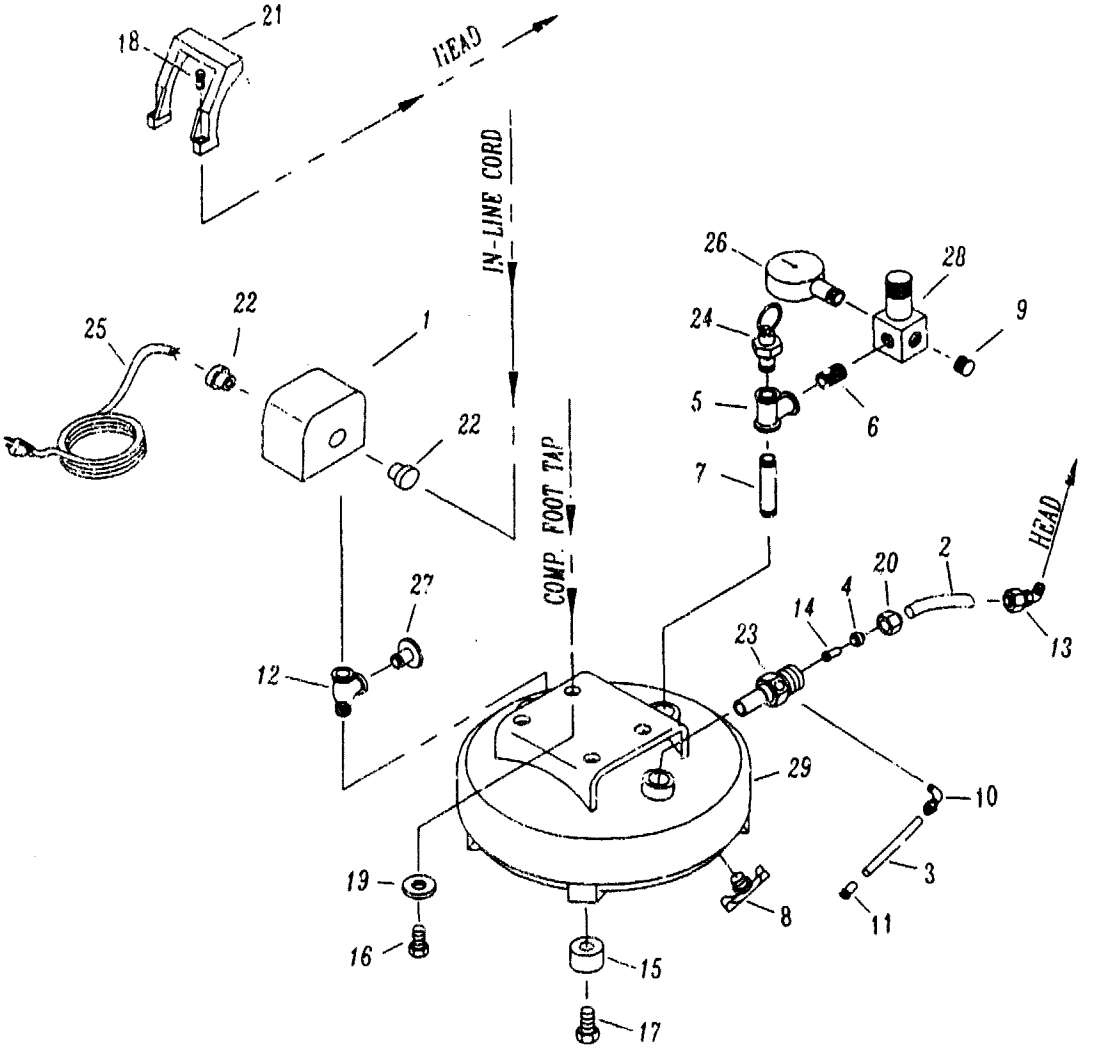
Item	Part No.	Description	Qty.
15	824604	Bumper	4
16	825349	Screw - Base	4
17	825406	Screw - Bumper	4
18	826023	Lockwasher - Base	4
19	826654	Nut	1
20	833967	Strain Relief	2
21	833968	Check Valve Assembly	1
22	833780	Cord	1
23	838179	Gauge - Regulator	1
24	838957	Safety Valve	1
25	838142	Gauge - Tank	1
26	841131	Regulator	1
27	661995-500	Tank Assembly	1



DRAWING AND PARTS LIST FOR T-30 PANCAKE TANK DRAWING

Item	Part No.	Description	Qty.
1	902888	Pressure Switch	1
2	818847	Exhaust Tube 11.5"	1
3	818848	Intake Tube	1
4	019736	Fitting - Ball Assembly	1
5	824015	Pipe Tee	1
6	824016	Close Nipple	1
7	824044	Pipe Nipple	1
8	824400	Drain Fitting	1
9	824327	Pipe Plug - Regulator	1
10	821341	Elbow	1
11	824810	Tubing Insert	1
12	824813	Street Tee	1
13	824844	Elbow Connector - Head	1
14	824847	Tubing Insert	1
15	824864	Rubber Bumper	4

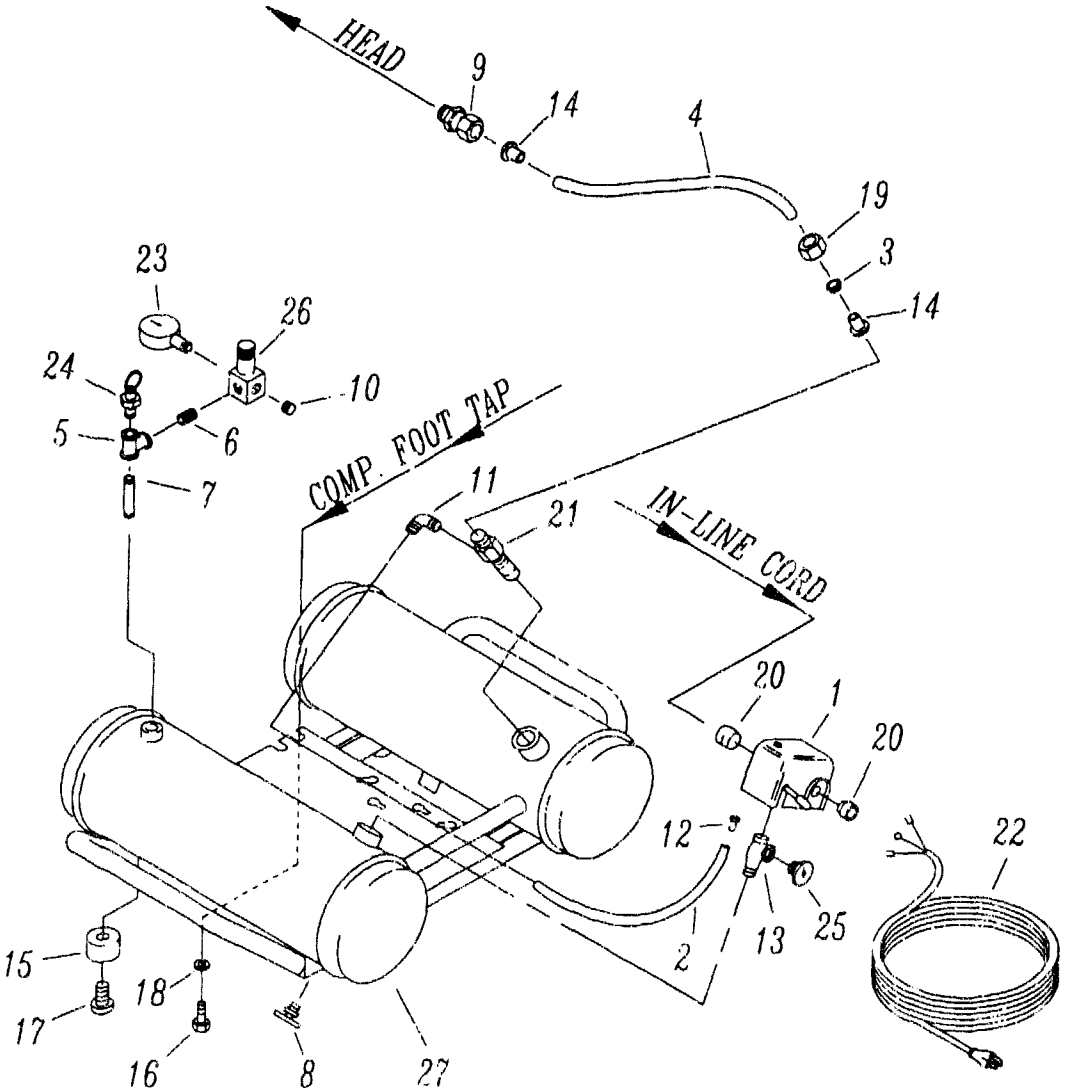
Item	Part No.	Description	Qty.
16	825349	Screw - Base	4
17	825406	Screw - Bumper	4
18	[illegible]	Screw - Handle	2
19	[illegible]	Washer - Base	4
20	829884	Nut	1
21	832117	Handle	1
22	833647	Strain Relief	2
23	833688	Check Valve Assembly	1
24	833857	Safety Valve	1
25	833780	Cord	1
26	838139	Gauge - Regulator	1
27	838142	Gauge - Tank	1
28	841131	Regulator	1
29	881873-500	Tank Assembly	1



DRAWING AND PARTS LIST FOR T-30 WIDE TANK DRAWING

Item	Part No.	Description	Qty.
1	602686	Pressure Switch	1
2	615716	Unloader Tube	1
3	615790	Sleeve - Self Aligning	1
4	615752	Exhaust Tube 11"	1
5	624015	Pipe Tee	1
6	624016	Close Nipple	1
7	624041	Pipe Nipple	1
8	624200	Drain Tube	2
9	624318	Connector	1
10	624327	Pipe Plug - Regulator	1
11	624361	Elbow	1
12	624510	Tubing Insert	1
13	624513	Street Tee	1
14	624547	Tubing Insert	2

Item	Part No.	Description	Qty.
15	624654	Bumper	4
16	625349	Screw - Base	4
17	625406	Screw - Bumper	4
18	626025	Lockwasher - Base	4
19	626554	Nut	1
20	633557	Strain Relief	2
21	633588	Check Valve Assembly	1
22	633750	Cord	1
23	638139	Gauge - Regulator	1
24	638957	Safety Valve	1
25	638142	Gauge - Tank	1
26	641131	Regulator	1
27	661996-500	Tank Assembly	1



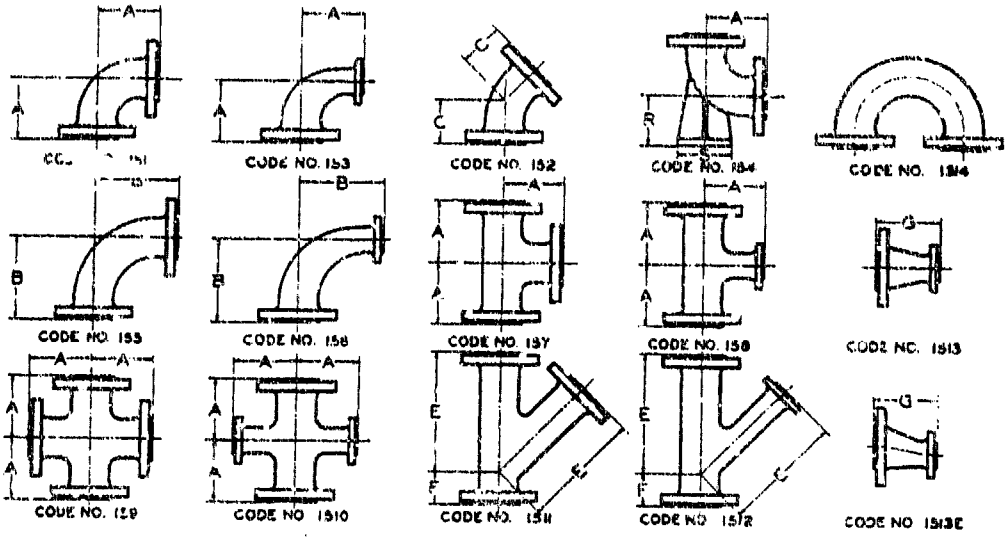
FLANGED FITTINGS

GLOVER MACHINE WORKS

SERIES 15—150 Pound

Cast Carbon and Alloy Steel Flanged Fittings

DIMENSIONS



All dimensions are in inches

NOMINAL PIPE SIZE	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14 OD	16 OD	18 OD	20 OD	24 OD
Inside diameter of fitting	½	⅝	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	13¼	15¼	17¼	19¼	23¼
Outside diameter of flange	3½	3⅞	4¼	4⅝	5	6	7	7½	8½	9	10	11	13½	16	19	21	23½	25	27½	32
Minimum thickness of flange	⅜	⅜	7/16	½	9/16	⅝	11/16	¾	13/16	15/16	15/16	1	1⅛	1⅜	1¼	1⅜	1⅜	1⅜	1⅜	1⅜
Diameter of raised face	1¾	1 15/16	2	2½	2⅞	3⅝	4⅛	5	5½	6 9/16	7⅝	8½	10⅝	12¾	15	16¼	18½	21	23	27¼
Diameter of bolt circle	2⅜	2¾	3⅛	3½	3⅞	4¾	5½	6	7	7½	8½	9½	11¾	14¼	17	18¾	21¼	22¾	25	29½
Number of bolts	4	4	4	4	4	4	4	4	8	8	8	8	8	12	12	12	16	16	20	20
Size of bolts	½	½	½	½	½	⅝	⅝	⅝	¾	⅞	⅞	1	1	1	1	1	1	1⅛	1⅛	1¼
A Center to face Elbow-Tee-Cross	3	3½	3½	3¾	4	4½	5	5½	6	6½	7½	8	9	11	12	14	15	16½	18	22
B Center to face Long Radius Elbow	4	4½	5	5½	6	6½	7	7½	8½	9	10½	11½	14	16½	19	21½	24	26½	29	34
C Center to face 45° Elbow	1½	1½	1¾	2	2½	2½	3	3	3½	4	4½	5	5½	6½	7½	7½	8	8½	9½	11
E Center to face Long leg of lateral			5¼	6¼	7	8	9½	10	11½	12	13½	14½	17½	20½	24½	27	30	32	35	40½
F Center to face Short leg of lateral			1⅜	1¾	2	2½	2½	3	3	3	3½	3½	4½	5	5½	6	6½	7	8	9
G Face to face Reducer			4½	4½	4½	5	5½	6	6¼	7	8	9	11	12	14	16	18	19	20	24
R Center to base			3½	3⅝	3¾	4¼	4½	4⅝	5⅛	5½	6¼	7	8⅜	9¾	11¼	12½	13¾	15	16	18¼
S Width of base			3½	3½	4½	4¾	4½	5	5	6	7	7	9	9	11	11	11	13½	13½	15½

Series 15 cast steel flanged fittings are provided with 1/16" raised faces which ARE included in minimum thickness of flange, center to face and face to face dimensions. Special facing information is shown on pages 24 and 25.

Reducing fittings have the same center to face dimensions as those of straight size fittings of the largest opening.

For drilling of flanges see page 27.

PRESSURE DIFFERENTIAL GAGES

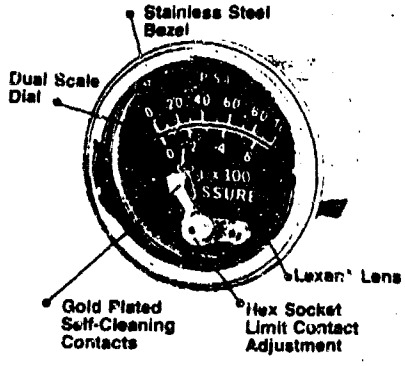
FRANK W murphy MFR.

Installation Sheet: 2025P-INS
Effective: 10-15-83
3456789 Revision: 02-15-88

INSTRUCTIONS FOR INSTALLATION & MAINTENANCE OF PRESSURE & VACUUM SWICHGAGES®

SERIES: 20-P, 25-P, A20-P, A25-P INCLUDING V, VWC, ABS, EO, DP MODELS

TYPICAL PRESSURE SWICHGAGE®

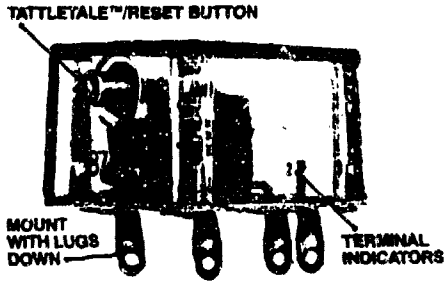


A SWICHGAGE® is an indicating mechanical gage, with adjustable limit contacts which may be preset at the factory. It is the sole responsibility of the installer/user to insure the proper contact setting before placing it in operation. SWICHGAGES® are available in various sizes and shapes to adapt to most applications, for pressure, temperature, liquid level, vibration or speed. These are dry contact type switches for light duty electrical switching and should be used with a Murphy Magnetic Switch or Transformer Relay. Both electrical and mechanical experience is necessary for proper installation and maintenance.

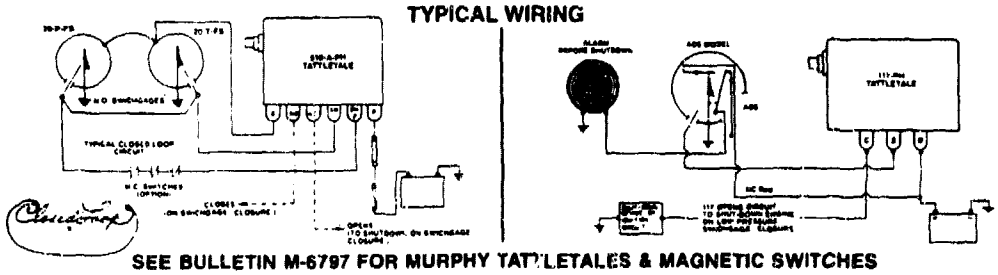
TYPICAL TATTLETALE MAGNETIC SWITCH®

TATTLETALE® Magnetic Switches
Murphy manufactures several, patented magnetic switches for protection of the light duty SWICHGAGE® contacts and to ensure positive shut-down of equipment. There are magnetic switches for Capacitor Discharge ignition, Magneto, or battery systems, and models for electric motor driven equipment. TATTLETALES® are pop-out indicators that show the cause of shut-down. If several TATTLETALES® are used in conjunction with several different SWICHGAGES®, the first one out will lockout all other magnetic switches. Be sure the type of Magnetic Switch matches the power source used to trip it.

• **Note:** At equipment start-up, the magnetic switch reset button must be held in until normal operation occurs, unless closed SWICHGAGES® are locked out by time delay or lockout button. (Not applicable for Mag. or C.D. power)



TYPICAL WIRING



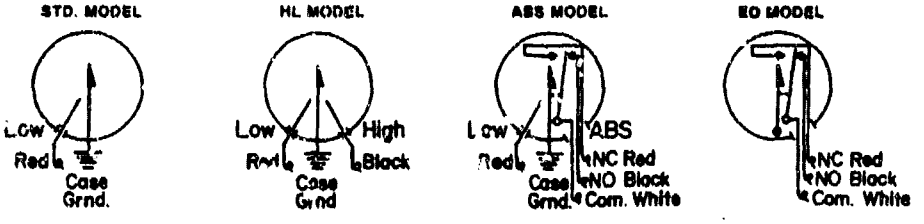
SEE BULLETIN M-6797 FOR MURPHY TATTLETALES & MAGNETIC SWITCHES

BASIC DESCRIPTION

20 & 25 SERIES PRESSURE/VACUUM SWICHGAGES®
20 Series (2-1/16", 52mm mounting hole) and 25 series (2-11/16", 68mm. mounting hole) have steel cases and are diaphragm actuated. The pointer/contact grounds through the case to complete the switch circuit. The limit contact(s) is wired to power, through a Murphy Magnetic Switch. See diagrams for SWICHGAGE® wire color code. Contacts are rated 2A @ 30V resistive (pilot duty); gauge connection is 1/8-27 NPT. See installation and typical wiring diagrams for wire up of SWICHGAGE® and Murphy magnetic switch.

A20 & A25 SERIES PRESSURE/VACUUM SWICHGAGES®
A20 series (2-1/16", 52mm mounting hole) and A25 series (2-11/16", 68mm mounting hole) have polycarbonate cases and are diaphragm actuated. These cases have molded, isolated termina's for switch contact: the pointer-contact is wired to common or ground; the limit-contact(s) is wired to power, through a Murphy magnetic switch. See SWICHGAGE® diagrams for terminal codes. Contacts 2A @ 30V resistive (pilot duty), gauge connection 1/8-27 NPT. See installation and typical wiring diagrams on this sheet, for wire up of SWICHGAGE® and Murphy magnetic switch.

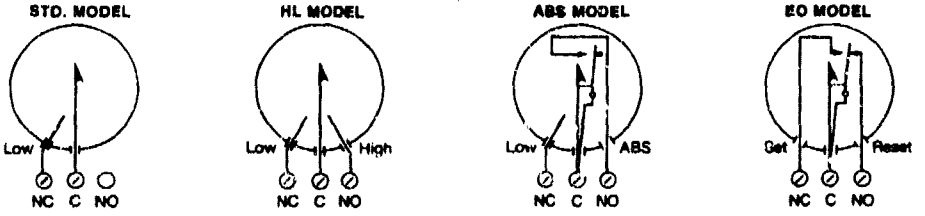
STANDARD ELECTRICAL DIAGRAMS: 20 & 25 — PRESSURE/VACUUM SERIES
THESE DIAGRAMS ARE SHOWN WITH POINTER IN THE NORMAL OPERATING RANGE.



Std. Switch Rating: Pilot Duty, 2A @ 30 VAC/DC resistive

Micro-Switch Rating: 3A @ 30 VDC inductive
4A @ 125 VAC inductive

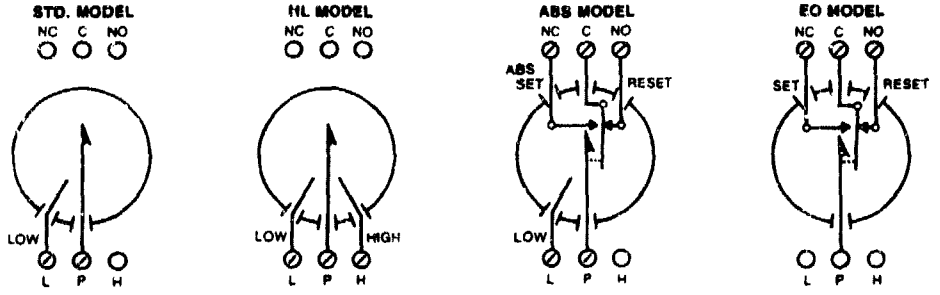
STANDARD ELECTRICAL DIAGRAMS: A20 — PRESSURE/VACUUM SERIES
THESE DIAGRAMS ARE SHOWN WITH THE GAUGE POINTER IN THE NORMAL OPERATING RANGE.



Std. Switch Ratings: Pilot Duty 2A @ 30 VAC/DC resistive

Micro-Switch Rating: 3A @ 30 VDC inductive
4A @ 125 VAC inductive

STANDARD ELECTRICAL DIAGRAMS: A-25 — PRESSURE/VACUUM SERIES
THESE DIAGRAMS ARE SHOWN WITH POINTER IN NORMAL OPERATING RANGE



Std. Switch Rating: Pilot Duty, 2A @ VAC/DC resistive

Micro-Switch Rating: 3A @ 30 VDC, inductive
4A @ 125 VAC, inductive

SPECIAL APPLICATION SWICHGAGES®: ABS, EO, DP, VWC, ST, P-7

ALARM BEFORE SHUT-DOWN TWO SWITCH OPTION

ABS: SWICHGAGE with Alarm Before Shut-down

The ABS has a standard, front limit-contact for low pressure equipment shut-down and an internal, SPDT micro switch for Alarm Before Shut-Down (see Wiring Diagram). When the low side of the micro switch SETS (preset point, on falling pressure), the NC side of the switch completes a circuit to activate an alarm. From this point the pressure must increase approximately 10% of scale before the micro switch will RESET and open the circuit; if pressure falls, the shut-down circuit will be completed.

NOTE: The front contact shut-down limit setting (adjustable) and micro switch low point are preset at the factory; if settings other than standard are necessary, then specify when ordering.

FILTER DIFFERENTIAL PRESSURE

DP: Differential Pressure SWICHGAGE

Installation: 1) connect the input side of the filter to the center port; 2) connect the filter output pressure to the upper port — CAUTION: use a 7/16" wrench on the upper port's wrench flats to prevent damage to the gauge. DO NOT over tighten port connections; 3) set the limit contact to the manufacturer's filter specifications; 4) connect wiring to alarm and/or shut-down devices.

DRY AIR CLEANER RESTRICTION

VWC: Water Column Calibrated, Vacuum SWICHGAGE

Installation: 1) mount the VWC away from engine vibration; 2) run the vacuum line from the gauge to a point between the air cleaner and (a) carburetor on carbureted engine, (b) turbocharger on turbocharged diesels, (c) the engine on naturally aspirated diesels. NOTE: a flexible section is essential at some point in the vacuum line to eliminate vibration. Be sure the SWICHGAGE is grounded in a 12 or 24 volt system, and that the alarm used is of the same voltage as the battery.

MICRO-SWITCH® LIMIT CONTROL

EO: SNAP-ACTION Pressure SWICHGAGE

An EO is the combination of a MURPHYGAGE® and a SPDT micro switch. The switch will SET (see wiring Diagram) at its preset low pressure point on falling pressure. As the pressure rises, the switch will RESET approximately 10% of scale above the low pressure SET point. (The 10% difference is inherent in the physical movement of the micro switch.) By knowing the low pressure SET point this 3 wire SWICHGAGE can be used to make or break a circuit.

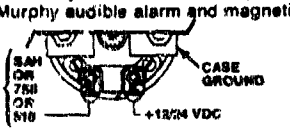
For Example, you have a 0-100 psi EO with a SET point of 15 psi; the switch will RESET at +10% of scale or 25 psi. This EO could be wired to light a lamp on low pressure start-up, and then put out the lamp as pressure rises past 25 psi.

The SPDT micro switch is rated 3 A @ 30 VDC inductive and 4 A @ 125 VAC inductive.

FLASHING LED ALARM

ST: LED Flashes On SWICHGAGE® Closure

The ST has a standard, front limit-contact for low pressure alarm. For shut-down or auxiliary alarm, wire to compatible rating, see examples of Murphy audible alarm and magnetic switches given below.



START-UP PRESSURE LOCKOUT

20-P7: Semi-Automatic Lockout

On start-up pressure, the SWICHGAGE® low limit contact can be by-passed by pushing the lockout button. The lockout will trip automatically on rising pressure. Lockout release level is factory set; check at initial start-up.

TROUBLE SHOOTING TIPS (Where problem appears to involve Murphy products)

PROBLEM	PROBABLE CAUSE & POSSIBLE CORRECTION
Engine will not start	• Blown fuse in magnetic switch circuit; replace with 14 A fuse. • False ground in control circuit: repair. • Open circuit (CLOSED LOOP®): repair. • Control circuit overloaded by accessories: reroute accessories.
False Shutdown	• Intermittent shorting in wiring due to wear or insulation breakdown.: check all wiring, replace as necessary. • CLOSED LOOP® circuit has intermittent open or short: check all wiring, replace as needed. • Vibration causes the magnetic switch to trip: repair, replace or relocate switch as needed.
SWICHGAGE® closes but does not trip the magnetic switch or kill the engine.	• Incomplete circuit: locate open circuit and repair. • Magneto not providing power to primary terminal post: repair magneto. • C.D. type magnetic switch being used with magneto or battery: replace with correct magnetic switch.
SWICHGAGE® closes and kills engine, but it does not trip the magnetic switch.	• Magnetic switch binds, prevents trip: adjust or replace the switch. • Conventional magnetic switch is used with C.D. ignition: replace the switch with a C.D. designated switch.
TATTLETALE® tripped but engine is still running (mag. or C.D.)	• Lost ground to kill engine: repair.
Pointer will not operate properly; inaccurate readings.	• clogged lines or pulsation dampener: remove and clean or replace. • Kinked/crimped/broken pressure or vacuum line: replace line.
Pointer or contact burned-in-two.	• Without exception this condition is caused by incorrect wiring or a short circuit refer to wiring diagrams and recheck wiring: replace SWICHGAGE®.

If you need additional assistance, contact YOUR LOCAL MURPHY DEALER, or a Murphy representative at one of the offices listed on this form.

TYPICAL INSTALLATION

SWICHGAGE® INSTALLATION (Refer to drawing)

1. Secure the SWICHGAGE® in the panel, using the clamp and nuts provided.

NOTE: Be sure the SWICHGAGE® and panel are grounded.

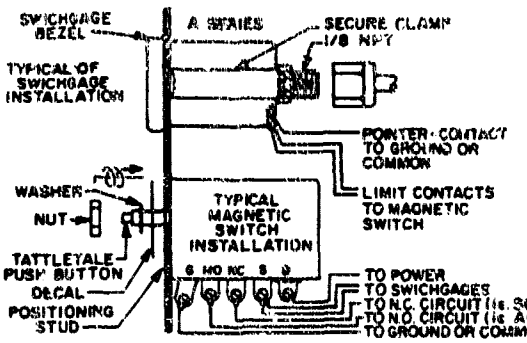
2. Connect the pressure or vacuum line, using a 1/8 NPT adaptor at the SWICHGAGE® end.

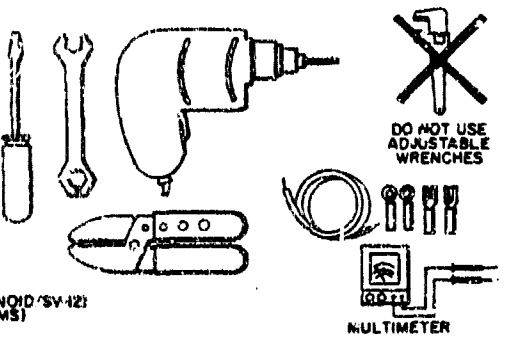
NOTE: Be sure that pressure line is clean and that pipe dope or teflon used on fittings does not block the line.

3. If not in a prewired panel, wire the limit switch(es) to a Murphy magnetic switch or relay.

NOTE: Pilot duty (2 A @ 30 V resistive) contacts must be protected from high current; disconnect power during wire-up.

TEST: Start equipment; wait for pointer to lift off low contact; check readings; close limit switch(es) to alarm/shutdown; adjust limit contact to correct limit point.





USE THE PROPER TOOLS — DO NOT OVERTIGHTEN

Murphy recommends mounting SWICHGAGES® and magnetic switches away from excessive vibrations and the use of panel shock mounts wherever vibration may occur. Handle all instruments with care; although durable, these products should not be subjected to rough handling, dropping, or severe vibrations.

Magnetic Switches: Mount with electrical lugs down. If necessary, drill the TATTLETALE® and pilot-stud holes (template provided); clean away burrs and fillings. Position the magnetic switch in the panel, making sure the pilot stud is in place. Add TATTLETALE® decal, then washer, then nut and tighten.

BASIC WIRING OF SWICHGAGE® AND MAGNETIC SWITCH

- Disconnect battery or other power during installation.
- Murphy components are easily wired-up and maintained.

Use good quality wire and terminals. Be sure all connections are Clean, Complete and Correct. The wiring and the type of magnetic switch differ for various applications, but a knowledge of basic electrical functions and of the circuits necessary for the specific job (what you want to happen), and common sense will make the system work the way you want it to work.

See examples of typical wiring and instructions packed with each magnetic switch.

IMPORTANT, PLEASE READ COMPLETELY

SWICHGAGES®, Murphy magnetic switches and valves, properly installed and maintained, are effective, work-ready tools in any preventive maintenance program. For optimum performance, check these tools periodically: look for frozen pointers, kinked or worn tubing, broken wiring or loose connections; close the contacts, then watch for expected results. Replace any damaged or worn parts; clean and repair as necessary. Murphy will repair or replace parts covered by the Murphy two year limited warranty.

- Check the wiring: it must be Correct and Complete: tight connections, unbroken insulation, no accidental grounds, do not run shut-down wires with ignition wiring.
- Check all tubing and connections for leaks.
- Mount magnetic switches and Murphy valves in an upright position, to prevent moisture collection and shorting.

Cleaning Lexan Lenses: Since many strong solvents and cleaners can haze and permanently damage the clear polycarbonate lens on SWICHGAGES®, please use one of the solutions listed here: **mild soap and water; mineral spirits; white kerosene; VM&P naphtha; heptane;hexane; varsol No. 2; menthyl/isopropyl/isobutyl alcohols: 1 & 3 denatured alcohols; freons TF & TE; petroleum ether (65°C boiling pt.).**

CAUTION: Many of these cleaners are flammable. DO NOT USE when the equipment is running or very hot. Keep away from sparks and flame.

Murphy Since 1939

FRANK W. MURPHY manufacturer
P.O. BOX 470248, TULSA, OKLAHOMA 74147, USA TEL. (918) 627-3550 FAX (918) 664-8148 TLX 402332

FRANK W. MURPHY southern division
P.O. Box 1819, Rosenberg, Texas 77471, USA
TEL. (713) 342-0297 FAX (713) 341-6006 TLX 7526379

FRANK W. MURPHY, LTD.
22 Beaufriar Rd., Wenden, Dorset BH21 6AY, U.K.
TEL. (0202) 827273 FAX (0202) 827690 TLX 418388

FRANK W. MURPHY PTE., LTD.
26 Sipoo Drive, Republic of Singapore 1545
TEL. (65) 841-3184 FAX (65) 841-8382 TLX RS24108

FRANK W. MURPHY France
31, rue Pasteur, 88670 Besançon, France
TEL. (1) 30 763636 FAX (1) 30 763669

MURPHY SWITCH OF CALIFORNIA
P.O. Box 736, Palmdale, California 93550, USA
TEL. (805) 273-4700 FAX (805) 947-7570

MURPHYEX PTY., LTD.
216 Parramatta Rd., Auburn, (NSW) Australia
TEL. (02) 647-1977 FAX 61-2-748-1486

10327/C84

LCD ELECTRONIC COUNTER

RED LION CONTROLS

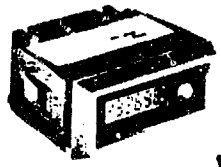
INTERNATIONAL HEADQUARTERS
20 Willow Springs Circle, York, Pa. 17402 (717) 767-6511
TWX: 510 667 4214 RLC YRK FAX: (717) 764-0839

EUROPEAN HEADQUARTERS
Cranford Lane, Heston, Hounslow, Middlesex TW58NQ
ENGLAND 01-759-0884 TWX: 24178 FARNO G

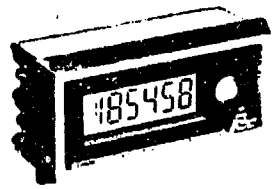
BULLETIN NO. CUB:/2-C
REVISED 6/90

MODELS CUB 1 & CUB 2 COUNTERS

OPEN UP NEW COUNTING HORIZONS, FROM COUNTING SIMPLE SWITCH CONTACT CLOSURES



CUB 1 MINIATURE ELECTRONIC COUNTER



CUB 2 GENERAL PURPOSE INDUSTRIAL COUNTER

- **TO HIGH SPEED PULSES FROM TTL, CMOS, OR OTHER ELECTRONIC SOURCES**
- **AT A PRICE LESS THAN EQUIVALENT E.M. [ELECTRO-MECHANICAL] COUNTERS**

The heart of the CUB is a tiny custom silicon chip developed by Red Lion Controls. This chip contains all of the counting and display circuits in an area less than .02 *(5mm)* square inches. Via *"micro-assembly"*, the chip and other peripheral parts are attached to a substrate with the electrical connections being made ultrasonically - using wire approximately 1/3 the diameter of a human hair. The result is an entirely new concept in counting, that is not only cost effective, but opens the door to counting applications that until now were not economically feasible.

AND HERE ARE SOME MORE ADVANTAGES:

SELF POWERED

Self-Contained batteries eliminate the need for external power and prevent loss of count if power fails. Also provides for remote or portable applications. Battery operation also means elimination of shock hazard and allows the use of 2-conductor bell wire for count signals and micro-power input signals.

Batteries are easily replaceable *(2 "N" Cells, alkaline)* and average battery life is four years.

HIGH SPEED

The 5000cps count speed is at least 100 times faster than *"high performance"* E.M. counters. This opens up vast new application areas that previously were impossible, or at best, accommodated by expensive electronic counters costing 5 to 10 times as much.

FLEXIBILITY

Various count inputs allow use with switch contacts or high speed pulse outputs from electronic sensors and circuits. The reset function can be disabled, set up for front panel reset, remote reset, or both.

NO-WEAR, NO-NOISE

The CUB's micro-circuits can accurately and silently accumulate enough counts in one hour to completely wear out an ordinary E.M. counter. Moreover, it can repeat this performance 3500 times *(4 years)* with just one set of batteries.

RELIABILITY

Internal *"micro-assembly"* construction withstands many times the "G" force of shock and vibration compared to conventional construction.

CUB counters also feature elastomeric contacts. This eliminates long term problems associated with contact corrosion.

Battery operation, a high degree of input filtering, plus an inherent common mode rejection ratio of more than 120dB @ 50/60Hz, provides ultra-high immunity from electrical noise interference.

RUGGED, SEALED FRONT-PANEL CONSTRUCTION

Housed in a die-cast metal case, CUB counters are front panel sealed and designed to meet NEMA 4/IP65 specifications, for wash-down and/or dust when properly installed.

SPECIFICATIONS

1. **DISPLAY:** 6-digit LCD
   CUB 1 - 0.2" *(5mm)* high CUB 2 - 0.35" *(9mm)* high
2. **POWER SOURCE:** No external power required. Operates from 2 "N" type alkaline batteries (supplied separately). Battery life up to 4 years or more. *(See Note, at right.)*
3. **COUNT & RESET INPUT SIGNALS:** Adapts to Count-Switch Contact Signals, Open-Collector Transistor Outputs, and Bi-Polar Drive Outputs as shown in the diagrams on preceding page. Counter increments and resets on negative going *(pull down)* transition of count or reset signal.
4. **OPERATING TEMPERATURE RANGE:** 0° to 50°C (32° to 122°F)
5. **STORAGE TEMPERATURE RANGE:** -20° to +60°C (-4° to +140°F)
6. **COUNT SPEED:** Up to 50cps with switch contact input *(counters have internal de-bounce circuits)* or up to 5000cps with solid-state electronic input *(See diagrams on preceding page)*.

NOTE: Only Alkaline Cells are recommended for use with CUB Counters. DO NOT USE CARBON-ZINC BATTERIES since they have short life times and can leak electrolyte causing internal corrosion damage. When using switch contacts for count input or remote reset, normally open contact circuits are recommended. Switch contacts that remain normally-closed and are opened only briefly to signal a count, can reduce battery life to somewhat less than 4 years.

USE CUB COUNTERS WITH:

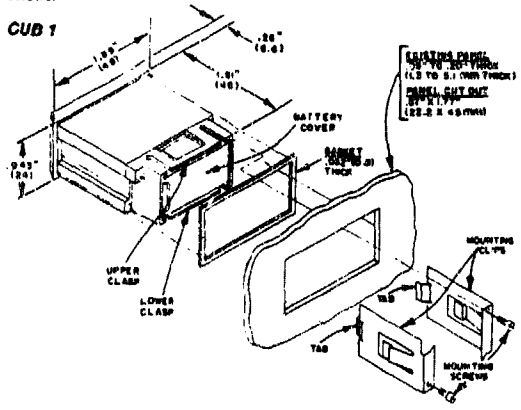
***VCM** - VOLTAGE CONVERTER MODULES for isolated, A.C., control voltage count inputs to 270VAC.*
***LCM** - LOGIC CONVERTER MODULES for interface with standard logic voltages & outputs.*
***PSMA** - POWER SUPPLY & INTERFACE MODULE for operation with electronic sensors.*
[See Accessory Section Of The Catalog]

DIMENSIONS, INSTALLATION, & BATTERY INSERTION

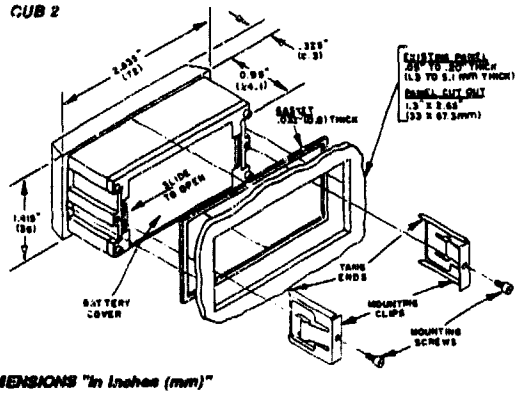
After cutting opening in panel, slide the panel gasket over the rear of the counter body to the back of the bezel. Then slide counter through the panel cut-out. Install mounting clips on each side of counter body with mounting screws.

Make sure the side rails or tabs of the clips fit into the recesses in the side of the counter body so that the *"Tang Ends"* or *"Tabs"* wedge between the panel opening and body as the screws are tightened.

CUB 1



CUB 2



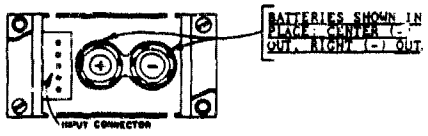
DIMENSIONS "in inches (mm)"

BATTERY COVER REMOVAL & BATTERY INSERTION

CUB 1

The battery cover is held in place by upper and lower clasps that capture mating lock ramps on the cover. To remove, insert thumbnail and index finger nail in the gaps between the upper and lower clasps and the battery cover, and deflect the clasps slightly to clear the edges of the ramps while pulling out on the cover. To replace cover, simply push into place until both clasps snap into engagement with lock ramps.

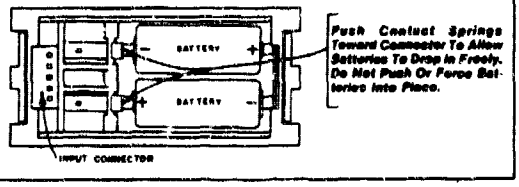
CAUTION: Do not deflect clasps more than necessary to clear lock ramps. Excessive deflection can cause clasps to break off.



CUB 2

Slide battery cover to the left until the right hand lip disengages and pops out. To reinstall cover, insert left hand lips into case first, push cover to the left until right hand lip drops down and cover snaps back into place. Install batteries as shown below observing proper polarity.

NOTE: Push battery spring clips to the left (toward connector) to completely free the batteries when removing or installing batteries. Conductive rubber battery contacts can be torn from their retaining pins if batteries are forced in.



ELECTRICAL CONNECTIONS

Wiring runs to count-switches or to remote reset contacts can be made with almost any kind of wire and over distances of hundreds of feet, due to the advantages of low-voltage low-current operation. The inherent noise immunity and heavy filtering built into CUB Counters, permits use of unshielded wiring, however the following precautions are advisable especially in high electrical-noise environments.

1. Avoid long wire runs in cable troughs or conduits with power circuits.
2. Mount the CUB in a panel that is grounded to the machine frame.
3. When using accessory devices such as LCM's or PSM's into the H.S. CNT. Input, the accessory devices should be mounted near the CUB Counter.

ORDERING INFORMATION

MODEL NO.	DESCRIPTION	PART NUMBER
CUB 1	CUB 1 Miniature Electronic Counter	CUB-1A-000/0
CUB 2	CUB 2 Gen. Purpose Industrial Electronic Counter	CUB-2A-000/0
BAA	"N" Type Alkaline Batteries (Note 1)	BAA-00-000/0
MBK 1	CUB 1 Beam Hardware Kit (Note 2)	MBK-1A-000/0
MBK 2	CUB 2 Beam Hardware Kit (Note 2)	MBK-2A-000/0
ICA	Spare Input Connector & Terminal Wires (Note 3)	ICA-00-000/0

For more information & pricing on Enclosures & Panel Mount Kits see Section "L" of the RLC Catalog or contact your local RLC distributor.

NOTES

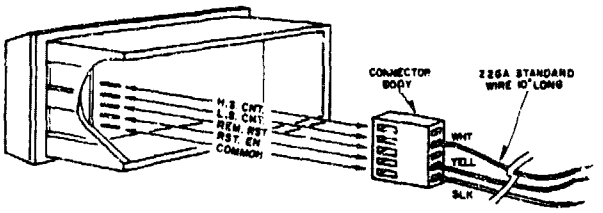
1. Batteries NOT supplied with counters, order separately. 2 required per unit.
2. Counters supplied with required hardware. Includes 2 mounting clips & screws, panel gasket, 2-wire nuts & blue terminal wire.
3. Counters supplied with connector body & white, yellow, & black wires. Kit ICA includes connector body & one each of black, white, blue, & yellow terminal wires.

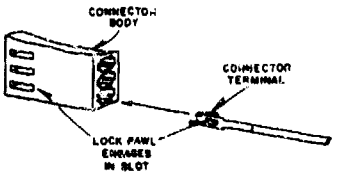
APPLICATION FLEXIBILITY VIA RECONNECT OPTIONS

Selection of desired operating modes is easily done by adding or moving terminal leads in the Input Connector Body. The connector body is polarized to prevent incorrect insertion, and locked in place by the battery cover to avoid accidental disengagement. Connectors are supplied with the 3 leads installed as shown below. A spare blue lead is supplied in the hardware pack.

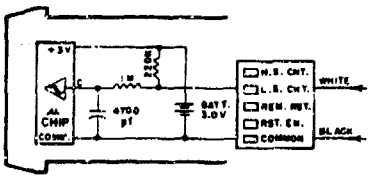
TO REMOVE TERMINAL, insert blade of a small screwdriver into slot of connector body, and gently push in to disengage lock pawl. Pull terminal out.

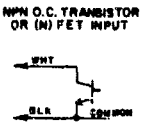
WHEN INSERTING TERMINAL into connector body, make sure the lock pawl is toward the slot in the body. Push terminal in until lock pawl snaps into slot.

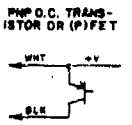




LOW SPEED COUNT INPUT, 50CPS MAX. [For 250cps see note in text]







Pulling the L.S. CNT. Input to Common with a mechanical or solid-state switch increments the counter. The low pass filter (1meg resistor and 4700pf cap) used with a Schmidt trigger circuit debounces mechanical switch signals. The switch load is 14uamps (max. voltage drop 0.5V) when ON. OFF-state leakage must be less than 2uamps at 3V.

Reed switches, mercury wetted contacts, snap action limit switches, and silver alloy relay contacts with wiping action are usually satisfactory for generating count input signals. Motor starter contacts, tungsten contacts, and brush-type contacts should NOT be use.

NOTE: By parallel connecting both H.S. CNT. and L.S. CNT. inputs, count speed can be increased to 250cps if de-bounce is not needed.

HIGH SPEED COUNT INPUT, 5000CPS MAX.

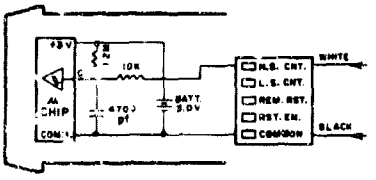
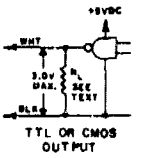
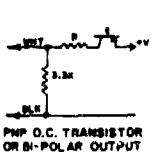


FIG 1



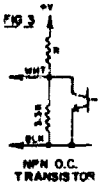
TTL OR CMOS OUTPUT

FIG 2



PNP O.C. TRANSISTOR OR BI-POLAR OUTPUT

FIG 3



NPN O.C. TRANSISTOR

R values for Fig 2 & 3	
+V	R
+5V	2.2K
+12V	10K
+18V	16K
+24V	24K

Moving the white wire to the H.S. CNT. input allows the CUB Counter to operate at speeds up to 5000cps when driven by bi-polar outputs or external circuits having an output impedance of 3.3Kohms or less. Input drive voltage must be limited to 3.0V maximum to avoid a charging current into the batteries which can cause premature battery failure or leakage. CMOS and TTL Logic outputs can be loaded with a resistor (R_L) to limit drive voltage, or a voltage divider can be used as shown for the PNP O.C. Transistor output.

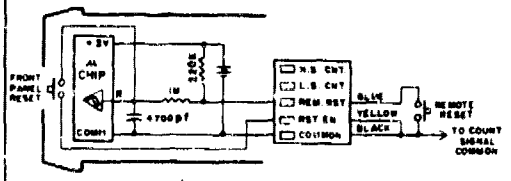
INPUT PULSE EXCURSION LIMITS

V_{IN} (High) = +2.7V min. +3.3V max.

V_{IL} (Low) = ±0.5V max.

NOTE: The PSMA Power Supply and Interface Module used for powering RLC sensors with CUB Counters, has proper interface output for direct drive to H.S. CNT.

RESET OPTIONS



Connecting the RST. EN. (Reset Enable) Input to Common activates the front panel Reset button. When the front panel Reset button is to be de-activated, remove the yellow wire from the RST. EN. Input.

When Remote Reset is required, the blue wire in the hardware pack is inserted in the REM. RST. Input. Pulling this input low causes the counter to reset. The REM. RST. can be pulled low by either a mechanical switch or solid-state transistor switch. Switch load and leakage are the same as for L.S. CNT. Input above.

NOTE: The NC protection circuit on the REM. RST. Input causes a delay at approximately 6msec in Reset response.

AIR ELIMINATOR VALVES

AIR VALVES

Air Vents

...vents air from steam and liquid lines. A vacuum check ... when pressure drops, preventing air from seeping back ... has a float that opens when air accumulates. Units for ...air and thermostatic construction that prevents escape ...ster. Construction is brass. Connections: Combination female pipe threads.

Low Pressure

...ir Steam • Maximum Pressure: 15 psi

...d of steam mains, tops of risers, and similar locations ...no-pipe vacuum systems. Use where venting does not ...at 5 psi.

...NET EACH $48.14

Minim Pressure

...al • For Steam
• Maximum Pressure: 125 psi

...ce from hot ... and liquid ...r softeners ...ply

...ACH $68.70

Use on steam pressure vessels and systems. Capable of expelling large volumes of air without passage of water or steam.

No. 4936K11 .....NET EACH $109.19

Precalibrated Air Valves

...s

...ure:

...ssure:

...ble over- ...in pipe vacuum. ...onnections have a lens pre- ...d) piston ...the taste ...stalled in ...ade.

...ET EACH
...574.75
...184.20
...144.50

• Maximum Air Pressure: 150 psi

Just the blast where intermittent, manually controlled blasts of air are needed.

Press knob on stem to open and release to close. Great for processing operations and test setups.

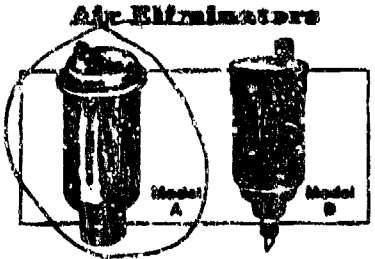
Body is nickel-plated brass with stainless steel spring and Buna-N O-rings. Discharge rate is 25-10 cfm at 100 psi pressure drop. Connections: ¼" female pipe threads.

INLINE—For mounting directly in line.

PANEL MOUNT—Has two lock nuts on stem for mounting on panel up to ⅜" thick.

Style	No.	NET EACH
Inline	4624K1	$79.20
Panel	4626K2	93.06

Air Eliminators



Automatically vent air to eliminate air pockets that can reduce system efficiency. Use for hot water heating and other systems where water and other liquids are used for heating or cooling: mains, pipe lines, risers, unit heaters, chillers, radiant panels, convectors, and coils.

MODEL A—Made of brass with a mason spring and neoprene valve seat that resists oil and antifreeze. Mount vertically. Connections: Pipe threads.

• Connection: ½" female at bottom
• Maximum pressure: 75 psi
No. 4626K1 .....NET EACH $16.05

• Connections: ½" female at bottom plus ¼" female at side.
• Maximum pressure: 75 psi
No. 4626K3 .....NET EACH $21.81

• Connection: ¼" female at bottom
• Maximum pressure: 150 psi
No. 4626K3 .....NET EACH $26.86

• Connection: ½" female and ¾" male combination at bottom
• Maximum pressure: 150 psi
No. 4626K4 .....NET EACH $28.42

MODEL B—Body, cover, and float mechanism are thermoplastic. Maximum temperature is 212°F. Not for use with oil or oil-base additives. Install vertically. Available with or without a built-in ...ress shutoff valve.

• Connection: ½" male at bottom.
• Maximum pressure: 50 psi

Description	No.	NET EACH
With Shutoff	5722K63	$13.51
Without Shutoff	4722K64	12.30

Lockable Air Bl...

• Maximum Pressure: 250 psi
• Maximum Temperature: 175°F

...that all compressed air lines with these economical valves—help you meet new OSHA standard for lockout and tagout.

In closed position, valve stops air flow and exhausts downstream air. Manually operated valves open and close with a short, one-inch movement of the slide.

The hole for your padlock is 0.20" diameter. Valves have cast zinc seats. The words Open and Closed indicate position of condition. Connections:

Pipe Size
½"
¾"
1"

Safety Shutoff Valves for Air Ho...

• Maximum Pressure: 300 psi

Operator is completely outsi... valve closes when ... flow exc... preset rate; automatically ... when air pressure is back to norm...

Valves protect personnel from a suddenly disconnected fitting or ... Regulation Section 1926.302 (b), Pa... ½" inside diameter shall have a valv... or branch line to relieve pressure ... hose. Female pipe threads.

Pipe Size	Closing Flow Rate CFM @ 90 PSI
ALUMINUM BODY AND BRASS TRIM	
• Maximum Temperature: 350°F	
¾"	35
1"	80
1¼"	200
1½"	340

Pipe Size	Closing Flow Rate CFM @ 100 PSI
BRASS BODY AND BRASS TRIM	
• Maximum Temperature: 178°F	
¼"	20
⅜"	50
½"	80
¾"	130
1"	210
1¼"	450

Slide Safety

• Maximum Pressure: 250 psi
• Temperature Rat... at
–65° to 165°F

Cast Iron Air Release Valves

A Low Capacity

...imum Pressure: 150 psi
...imum Temperature: 180°F

...e of small accumulations of air ...ed water systems. Excellent ...ation systems, may also be used ...rosion products and other liq... body is cast iron with stainless steel internal parts. Install valves at high points of the line. Valves operate while the system is in service and under pressure. Discharge capacity is 6.1 cfm at 150 psi. Connections: Female pipe threads.

Inlet	Outlet	Ht.	Wd.	No.	NET EACH
¾"	¾"	5¾"	5"	4604K63	$99.95
¼"	¾"	5¾"	5"	4605K64	92.24
¾"	¾"	5¾"	5"	4606K66	129.67
1"	¾"	5¾"	5"	4606K68	153.77

WATER DETECTION SENSOR

1334 Greenville Road
LaGrange, GA 30240
Telephone 706/884-3009
Fax 706/884-5516

FILTERDYNE® FILTRATION SYSTEMS

900-911
WATER DETECTION DEVICE

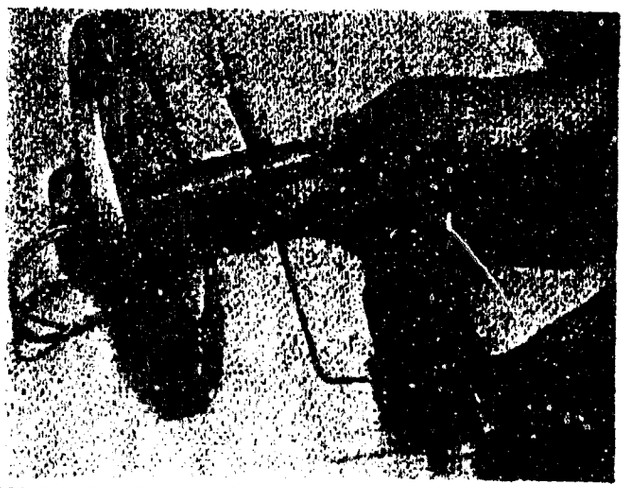
DETECTS HIGH WATER LEVELS IN FILTER SEPARATOR VESSEL SUMPS

DESCRIPTION:

The 900-911 Water Detection Device was developed to replace the float control and slug valves used on filter separators.

The 900-911 Water Detection Device detects water level in filter separator vessel sumps. When a high water level is detected an alarm light turns on. Personnel can then manually drain the water. The auxiliary contacts can operate an alarm or shut off the pumps, etc.

For years individuals have had difficulty trouble shooting float control and slug valves. The 900-911 is an electric device and is extremely reliable. The 900-911 is easier to diagnose and repair than hydraulically operated devices.



900-911 Water Detection Device Float Assembly shown above.

OPERATION:

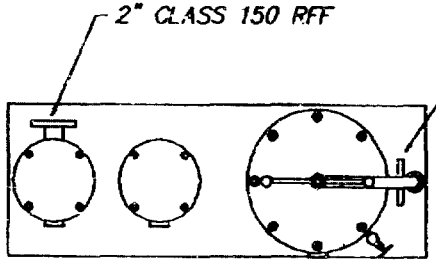
A donut shaped float is installed on a pre drilled plate. This plate assembly fits on the float control valve mount. The float rides on a stainless steel stem. When the water begins to rise in the sump, this float follows the interface between fuel and water. The contacts inside the stem are activated by the magnet in the float when the water reaches the alarm level. An electronic relay registers this contact closure because of the increase in resistivity of the closed contacts. This method of signal prevents high voltage inside a vessel filled with jet fuel and makes the unit intrinsically safe.

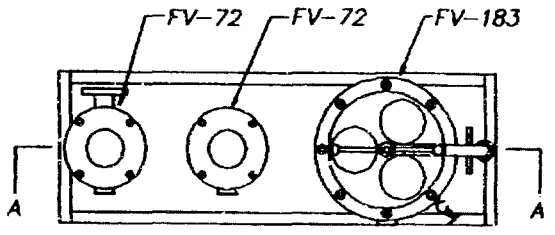
FILTRATION SYSTEM

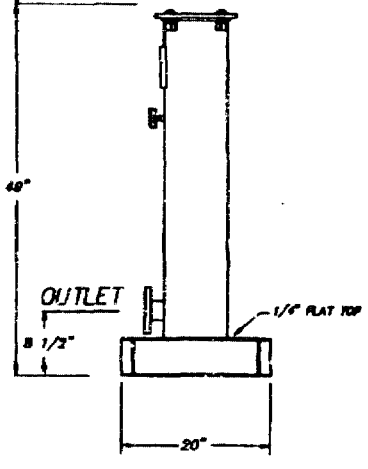
ITEM	DESCRIPTION	STANDARD	OPTION
1.	POLISH FILTER-1 MICRON	FE-630-631Y	FE-617-[illegible]
2.	CLAY FILTER	FE-735-[illegible]	FE-717-[illegible]
3.	SEPARATOR	FE-[illegible]-[illegible]	
4.	CONDENSER	FE-[illegible]-[illegible]	
5.	GASKET	122- 3 BUNA	122- 38 VITON
6.	GASKET	122- 6 BUNA	
7.	SIGHT TUBE ACRYLIC	130- 57	
8.	GAUGE 0-160 CBM	127- 55	
9.	ISOLATION VALVE	128- 92	
10.	ADAPTER CONVERT 3/8" THREADED BASE TO 17" FLAT SIDE*	190-233	

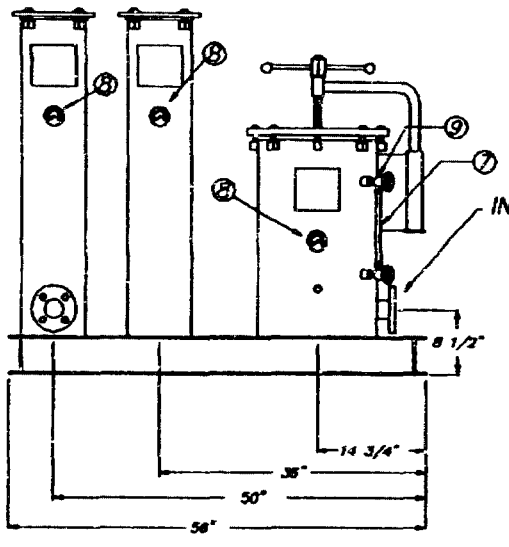
*USE OF 17" ELEMENTS DOE (DOUBLE OPEN END) REQUIRES ITEM 10 ADAPTER (190-233). REQUIRES 2 ELEMENTS PER STACK.

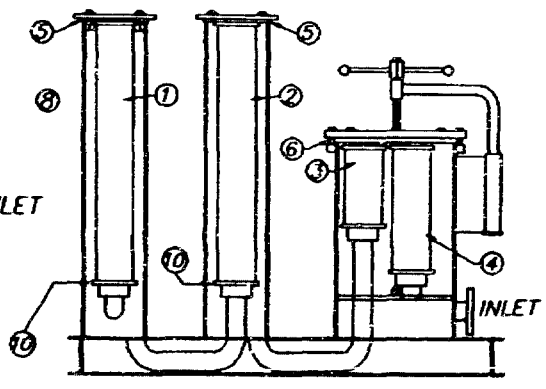
NOTE:
REQUIRES 36" CLEARANCE TO CHANGE FILTERS











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A-A

FILTERWISE FILTRATION SYSTEMS
LAGRANGE, GA
F-175 SPECIAL
REVIEW DRAWING CONCEPT ONLY
699

FUEL TANK

MORRISON

LINE STRAINERS — BOTTOM CLEAN OUT

285

LINE STRAINER BOTTOM CLEANOUT

CONSTRUCTION DETAILS
Body: Cast Iron
Cap: Cast Iron
Yoke: Malleable Iron
Strainer: Stainless Steel Type 304

Fig. 285

Size	Weight
1-1/2"	10 lbs.
2"	14-1/4 lbs.
2-1/2"	15-1/4 lbs.
3"	27 lbs.
4"	42 lbs.

Available with 6, 10, 20, 40, 60, 80 or 100 Mesh.
SPECIFY WHEN ORDERING

Fig. 285-AL

Available with 6, 10, 20, 40, 60, 80 or 100 Mesh.
SPECIFY WHEN ORDERING

285-

LINE ST BOTTOM C

CONSTRUCTIO
Body: Alu
Cap: Alum
Yoke: Alu
Strainer: Stainless
Se Screw and Nut:

Size
1-1/2
2"
2-1/2"
3"
4"

285-SS

LINE STRAINER STAINLESS STEEL BOTTOM CLEANOUT

CONSTRUCTION DETAILS
Body: Stainless Steel - Type 316
Cap: Stainless Steel - Type 316
Yoke: Stainless Steel - Type 316
Strainer: Stainless Steel - Type 316
Set Screw and Nut: Stainless Steel
Gasket: Teflon

Fig. 285-SS

Size	Weight
2"	15 lbs.
3"	27 lbs.

Available with 20 or 40 Mesh Type 316 S.S.
SPECIFY WHEN ORDERING

Fig. 285-W

Available with 6, 10, 20, 40, 60, 80 or 100 Mesh.
SPECIFY WHEN ORDERING

285-

LINE STR BOTTOM CL

CONSTRUCTION
Body: Ductile
Cap: Ductile
Yoke: Malleab
Strainer: Stainless St

Size
2"
3"

MORRISON

AG-CHEMICAL LINE STRAINER

285-PL

NYLON LINE STRAINER

CONSTRUCTION DETAILS
Body: Nylon
Cap: Nylon
Strainer: Stainless Steel

Fig. 285-PL

30 P.S.I. OPERATING PRESSURE

Size	Weight
1-1/2"	1-1/2 lbs.

APPENDIX C

After-Action Memorandum From the 24th ID DISCOM

AFZP-VS 7 JAN 1993

MEMORANDUM FROM COMMANDER, DIVISION SUPPORT COMMAND,
24TH INFANTRY DIVISION (MECHANIZED) SUPPORT COMMAND,
FORT STEWART, GEORGIA 31314

MEMORANDUM FOR COMMANDER, U.S. ARMY BELVOIR RESEARCH,
DEVELOPMENT AND ENGINEERING CENTER; SATBE-FL,
ATTN: MR. M.E. LE PERA, FORT BELVOIR, VIRGINIA 22060-5606

SUBJECT: Filtration/Additive Unit

1. As we bring our use of the Filtration/Additive Unit (FAU) to a close at Fort Stewart, I would like to personally thank you for your willingness to send it to us and allow us to utilize it in cleaning up our fuel contamination situation. I hope you found its use as beneficial as we did.

2. We found the FAU to be effective, to perform as advertised and believe that there is a definite place in the Army inventory for such a piece of equipment. As you continue development of the FAU and eventual fielding, there are several issues which we recommend be addressed.

a. Distribution. As we transition to a single fuel, the need to maintain clean fuel is doubly critical. Utilization of JP-8 for the entire force requires that all fuel within the Division be maintained at Aviation specifications all the time. We recommend a minimum of one FAU per Division, to be located in the Main Support Battalion. Under ideal conditions we would prefer a minimum of one FAU per each Forward Support Battalion, the Aviation Support Battalion (ASB) and one in the Main Support Battalion. Fielding of five per Division will strategically place the machines across the battlefield and will ensure that fuel purification capability is within reach of every unit on the battlefield. Also, fielding of five machines will allow the machines to be mutually supportive should the need arise and will also allow cross leveling of them should one become non-operational. We have learned that only one of "anything" can be a problem as the loss of it can bring an operation to a quick and complete halt.

b. Mission Assignment. Recommend the mission to operate the FAU be assigned to the Quartermaster Corps and ultimately the supply and service companies within the Division. Logic dictates that the mission of fuel purification be assigned to the agency which actually handles the fuel. This provides a single source for customer support and eliminates the "middle man" when a fuel purification mission is to be performed.

c. Militarization. Recommend you continue plans to "Militarize" the FAU. In its current configuration, fittings, filters, and controls are largely exposed. Their exposure increases the danger of damage to the FAU from tree limbs or other items which may be encountered in a field environment. In order for the FAU to be a viable piece of equipment, it must be capable of going to the field and operating in a tactical environment. For example, recommend you consider mounting a "box" over the fittings and hoses of the entire unit in order to protect it from damage. Looking at the Reverse Osmosis Water Purification Unit (ROWPU) design and structure may provide insight into this recommendation. Also recommend you consider redesigning the electrical system (taillights, etc.) to accept a 24 volt system in order for it to be compatible with tactical vehicles. The weight of the FAU requires it to be pulled by either a 2 1/2 Ton cargo truck, a 5 Ton Cargo or a 5 Ton Tractor. Recommend the towing lunette on the trailer be redesigned and relocated if necessary in order to ensure it accepts the towing pintle from the towing vehicle.

d. Miscellaneous. Recommend you add a flexible "wand type" device (3 to 4 feet in length) to the end of the intake hose. This device will assist greatly in reaching fuel cells of all types of vehicles (tracks and wheels) and will also help reach secondary fuel cells on combat vehicles. This capability will enable the FAU to provide a more complete filtration capability.

3. Again, I would like to express my gratitude. The entire petroleum community rose to the challenge and provided detailed and greatly needed assistance. Professionals from your organization, from Southwest Research and from the Army Petroleum Center worked long and difficult hours in order to keep the 24th Infantry Division (Mechanized) combat ready. Please feel free to call if we can be of assistance in the future. My POC is the Division Materiel Management Officer, MAJ Bryan L. Wiles, DSN 870-8993.

ROBERT L. FLOYD II
COL, OD
Commanding

APPENDIX D

After-Action Letter (Point Paper) From Camp Pendleton, 1st Reconnaissance Battalion

UNITED STATES MARINE CORPS
1ST RECONNAISSANCE BATTALION (LIGHT ARMORED)
1ST MARINE DIVISION (REIN), FMF
CAMP PENDLETON, CALIFORNIA 92055-5613

IN REPLY REFER TO:

4700
CO
4 Mar 93

POINT PAPER

From: Commanding Officer, 1st Reconnaissance Battalion
To: Commander, 1st Marine Division, AC/S Logistics

Subj: FUEL FILTRATION AND ADDITIVE UNIT (FAAU)

Encl: (1) U.S. Army Belvoir RD&E Center Special Bulletin
(2) U.S. Army Belvoir RD&E Center FAAU Pamphlet
(3) Trip Report from Mr. G. B. Bessee

1. Background. For at least a year the Battalion has experienced continual problems with the clogging of secondary fuel filters on the light armored vehicles (LAV). All indications are that the cause is fuel contaminated with water, microbiological agents, and sediment.

a. Bulk fuel delivered to our underground storage tanks is treated on site with a biocide and stabilizer that effectively checks microbiological growth. However, as the fuel is stored over relatively long periods of time both in the underground tanks and LAV fuel cells, it grows increasingly contaminated with water through condensation. Simultaneously, microbiological growth that has been terminated by the biocide additive, along with other particulate matter, settles to the bottom of storage tanks and fuel cells forming sludge. During vehicle operation the sludge is agitated and passes into the fuel system, ultimately clogging the two filters, particularly the secondary (five micron) filter.

b. The more often fuel is utilized the better, as condensation and algae growth is minimized, as is the formation of sediment. However, LAVs rarely come close to utilizing even half the fuel in their cells during a typical training week. Because this condition exists, and vehicle performance is so adversely affected due to clogged filters, to date there have been four approaches to the problem.

(1) Fuel cells are "topped off" at all times to limit water formation through condensation.

(2) Periodic purging of the storage tanks is required. This is not only a costly process, but can also result in the loss of already purchased fuel--now contaminated. There is also the added cost of disposing of it as hazardous waste. Additionally, there is significant lead time required in acquiring this service, and the recovered fuel is only run through a two filter process as opposed to the FAAU's six filters.

(3) Fuel filters are replaced. Filters, of which there are two, cost $25.00 each.

(4) LAV fuel cells are removed from the vehicle for purging. This is a manpower intensive process as it takes two mechanics 16 hours to complete the task.

2. Discussion. The problem of poor fuel quality is apparently widespread as discussed in enclosure (1). The crux of the problem at our level is to find a way to periodically filter the fuel in the storage tanks and LAV fuel cells. We have been proactive is pursuing strategies to identify solutions that are economical, and at the same time minimize labor costs and negative impact on training. Part of this effort has been to seek assistance and recommendations from various agencies responsible for fuel handling within the Division, MEF and Base structures (e.g., G-4, FSSG Bulk Fuel, MCB Bulk Fuel, MWSS Bulk Fuel, etc.). We also sought information through our various LAV specific contacts, for example, MCLB Barstow and Albany, the LAV Program Manager (LAV-PM), etc.

a. CWO2 Shihinski, our maintenance officer, seems to have found a potential solution through the LAV-PM (Engineering Section), U.S. Army Tank Automotive Command (TACOM), Warren, Michigan. He was informed by TACOM that an experimental filtering and additive device was under development by the U.S. Army Belvoir Research, Development and Engineering Center, Ft. Belvoir, Virginia (Enclosure (2)).

b. In December, CWO2 Shihinski contacted Mr. Maurice E. Lepera, Chief of Fuels and Lubricants Division, Ft. Belvoir RD&E. Arrangements were made for the FAAU to be shipped to us as part of the testing and evaluation process. Technical assistance was provided by Mr. Gary B. Bessee, a representative from Southwest Research Institute. Mr. Bessee confirmed that any cost would be absorbed by his agency as the device was still under developmental study at Ft. Belvoir. Prior to shipment it was clear that no cost would be incurred by either First Division or the LAV-PM's office.

c. During the approximately one week in late February that Mr. Bessee and the FAAU were on site here at Las Flores, our entire stock of fuel was filtered to the 0.5 micron level. This includes the fuel in our storage tanks and 94 LAV fuel cells. The key point is that removal of the fuel cell was not necessary for efficient filtering, and each fuel cell took less than 20 minutes to purge using only the machine and a single operator. We subsequently shipped the unit to 1st Tank Battalion with our own operator, where it is my understanding that over 14,000 gallons of fuel were cleansed.

3. Summary

a. The savings realized in labor, material, and fees to civilian contractors to clean storage tanks are obvious. It is also extremely easy to operate, requiring only about 15 minutes of OJT.

b. A system like the FAAU also has strong application to the Marine Corps as a primarily expeditionary force. Based on our research into the matter, there is no filtration system similar to the FAAU currently organic to the Marine Corps. It is our belief that it would have immediate application both at home and abroad.

(1) The fuel problems experienced during Desert Shield and Desert Storm are legend. The most senior staff noncommissioned officers who serve in the Battalion's maintenance section attest to the difficulties they experienced with contaminated fuel from MPF sources. They also describe severe problems with "bad" fuel delivered long after MPF sources were dry.

(2) As an expeditionary force we routinely deploy to nations that are unlikely to maintain an acceptable level of quality control in fuel storage and shipment. It is likely, therefore, that a deployed force would be required to utilize fuel purchased locally. It is also likely that this fuel would have some level of unacceptable contamination.

(3) In the event of conflict, contingency operations, etc., captured enemy materiel, particularly fuel stocks, have proven useful in relieving the pressure on friendly logistic systems. These stocks could suffer from some degree of either intentional or unintentional contamination.

c. The effectiveness of the FAAU is clearly evidenced by enclosure (3). The point of this paper is to pass on what we believe to be very useful information and recommend involvement in the development and fielding of the FAAU.

J. F. Kelly

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